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U. S. DEPARTMENT OF ENERGY NEVADA FIELD OFFICE ANNUAL SITE ENVIRONMENTAL REPORT - 1991, VOLUME 1 - MAY 1992 - (USED AS A REFERENCE IN OU1 AND OU2 FS REPORTS)

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Volume I

U.S. DEPARTMENT OF ENERGY NEVADA FIELD OFFICE ANNUAL SITE ENVIRONMENTAL REPORT - 1991

Volume I

Editors: Stuart C. Black, Alan R. Latham and Yvonne E. Townsend

May 1992

Work Performed Under
Contract No. DE-AC08-89NV10630

prepared by:

Reynolds Electrical & Engineering Co., Inc.
Post Office Box 98521
Las Vegas, Nevada 89193-8521

DISCLAIMER

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FOREWORD

Prior to 1989 annual reports of environmental monitoring and assessment results for the Nevada Test Site (NTS) were prepared in two separate parts. Onsite effluent monitoring and environmental monitoring results were reported in an onsite report prepared by the U.S. Department of Energy, Nevada Field Office (DOE/NV). Results of the offsite radiological surveillance and Long-Term Hydrological Monitoring programs conducted by the U.S. Environmental Protection Agency (EPA), Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, were reported separately by that Agency.

Beginning with the 1989 annual site environmental report for the NTS, these two documents were combined into a single report to provide a more comprehensive annual documentation of the environmental protection program conducted for the nuclear testing program and other nuclear and non-nuclear activities at the NTS. The two agencies have coordinated preparation of this third combined onsite and offsite report through sharing of information on environmental releases and meteorological, hydrological, and other supporting data used in dose-estimate calculations.

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The skill, dedication, and perseverance of Angela L. McCurdy in word processing and desktop publishing support were crucial to the production of this report. The review and advice offered by Basic Environmental Compliance and Monitoring Program (BECAMP) and EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV), reviewers were valuable. Compilation and verification of onsite data were provided by Sheryl L. Pfeuffer and Frank R. Grossman. The Geographic Information System (GIS) graphics were developed and provided by Steven M. Kowalkowski, EG&G/Energy Measurements, Inc. Darryl Randerson of the Weather Services Nuclear Support Office, National Oceanic and Atmospheric Administration, provided the wind rose information seen in Chapter 2.

The cooperative support of Charles F. Costa, and Daryl J. Thomè of the EMSL-LV in production of this combined onsite and offsite environmental report was appreciated.

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MEASUREMENT UNITS AND NOMENCLATURE

Radioactivity data in this report are expressed in curies, microcuries (one millionth of a curie), and picocuries (one millionth of a millionth). The curie (Ci) is the fundamental unit used to express the rate of radiations being produced from atomic nuclei transformations each second. A curie is 37 billion (37×10^9) nuclear transformations per second. The unit of becquerel is also used. A becquerel (Bq) is equal to one disintegration per second; therefore, it takes 3.7×10^{10} bequerels to make one curie.

The roentgen (R) is the fundamental unit used to describe the intensity of gamma radiation at a given measurement point (in air). The radiation exposure rate to external sources of penetrating radioactivity is expressed in milliroentgens per hour (mR/h), or one-thousandth of a roentgen per hour. A typical radiation exposure rate from natural radioactivity of cosmic and terrestrial sources is 0.005 to 0.025 mR/h.

The rem (for roentgen equivalent man) is a unit describing dose equivalent, or the energy imparted to human tissue when exposed to radiation. Dose is expressed in rem, millirem (mrem), or microrem (µrem). A typical annual dose rate from natural radioactivity (excluding exposure to radon in homes) is 100 to 130 mrem per year. The unit of sievert (Sv) is also used. One sievert is equivalent to 100 rem.

The elements and corresponding symbols used in this report are:

Element	Symbol	Element	Symbol
Actinium	Ac	Lead	Pb
Americium	Am	Polonium	Po
Argon	Ar	Plutonium	Pu
Boron	B	Protactinium	Pa
Beryllium	Be	Radium	Ra
Bismuth	Bi	Rhodium	Rh
Cadmium	Cd	Radon	Rn
Carbon	C	Ruthenium	Ru
Calcium	Ca	Sulfur	S
Cerium	Ce	Antimony	Sb
Cobalt	Co	Strontium	Sr
Cesium	Cs	Technetium	Tc
Hydrogen	H	Thallium	Tl
Iodine	I	Thorium	Th
Potassium	K	Thulium	Tm
Krypton	Kr	Tritium	^3H
Lithium	Li	Uranium	U
Lutetium	Lu	Xenon	Xe
Nitrogen	N	Zinc	Zn
Oxygen	O		

LIST OF ACRONYMS AND EXPRESSIONS

AAR	AIHA Asbestos Analysts Registry
AEC	U.S. Atomic Energy Commission
AIRFA	American Indian Freedom Act
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
ALI	Annual Limit of Intake
ANSI	American National Standard Institute
ASD	REECo Analytical Services Department
ASME	American Society Mechanical Engineer
ASN	Air Surveillance Network
AVO	Amador Valley Operations, EG&G/EM
BECAMP	Basic Environmental Compliance and Monitoring Program
BNA	base/neutral/acid
BOD	biochemical oxygen demand
BWMF	Bulk Waste Management Facility
BWMS	Bulk Waste Management Site
CAA	Clean Air Act
CAP	College of American Pathologists
CAP88-PC	EPA software program for estimating doses
CCS	Calibration check standard
CCSD	Clark County Sanitation District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COD	chemical oxygen demand
CP	Control Point
CRMP	Community Radiation Monitoring Program (EMSL-LV)
CRMS	Community Radiation Monitoring Station
CX	Categorical Exclusion
DAC	Derived Air Concentration
DCG	Derived Concentration Guide
DF	diesel fuel
DNA	Defense Nuclear Agency
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOELAP	DOE Laboratory Accreditation Program
DOE/NV	DOE, Nevada Operations Office
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
DQO	Data Quality Objectives
DRI	Desert Research Institute
DSC	discrete state compartment
DWB	DOE, Defense Waste Branch
EA	Environmental Assessment
ECO	REECo Environmental Compliance Office
EDE	Effective dose equivalent
EG&G	EG&G, Inc.
EG&G/EM	EG&G/Energy Measurements, Inc.
E-MAD	Engine Maintenance and Disassembly
EML	DOE Environmental Measurements Laboratory
EMSL-LV	EPA Environmental Monitoring Systems Laboratory, Las Vegas
EOD	Explosive Ordnance Disposal

EPA	U.S. Environmental Protection Agency
EPD	DOE Environmental Protection Division
EPTox	extraction procedure toxicity
ERP	Environmental Restoration Program
ESA	Endangered Species Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FOAV	Finding of Alleged Violation
GCD	Greater Confinement Disposal
GCR	Groundwater Characterization Project
GIS	geographical information system
GOES	geostationary operational environmental satellite
GSD	Goleta Sanitation District
GZ	ground zero
HEPA	high-efficiency particulate aerosol
HF	hydrofluoric acid
HPD	REECo Health Protection Department
HRMP	Hydrology/Radionuclide Migration Program (DRI)
HTO	tritiated water
ICP	inductively coupled plasma
ICRP	Internal Commission on Radiation Protection
ID	identification
IHD	REECo Industrial Hygiene Department
IRCR	International Reference Center for Radioactivity
KAFB	Kirtland Air Force Base
KO	Kirtland Operations, EG&G/EM
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations, EG&G/EM
LCS	laboratory control standard
LDAS	REECo Laboratory Data Analysis System
LDR	Land Disposal Regulations
LGFSTF	Liquified Gaseous Fuels Spill Test Facility
LINAC	DOE-EG&G/EM linear accelerator
LLD	lower limit of detection
LLNL	Lawrence Livermore National Laboratory
LLW	low-level (radioactive) waste
LTHMP	Long-Term Hydrological Monitoring Program (EMSL-LV)
LVAO	Las Vegas Area Operations, EG&G/EM
MCL	Maximum Contaminant Levels
MDA	minimum detectable activity
MDC	minimum detectable concentration
MGD	million gallons per day
MBAS	methylene blue active substances
MSL	mean sea level
MSM	Mounds Strategic Material
MSN	Milk Surveillance Network (EMSL-LV)
MWMF	Mixed Waste Management Facility
MWMU	Mixed Waste Management Unit
NAC	Nevada Administrative Code
NAEG	Nevada Applied Ecology Group
NAFB	Nellis Air Force Base
NCR	nonconformance report
NCRP	National Council on Radiation Protection and Measurement
NDEP	Nevada Division of Environmental Protection
NEPA	National Environmental Policy Act

List of Acronyms and Expressions, cont.

NESHAP	National Emission Standards for Hazardous Air Pollutants
NEST	Nuclear Emergency Search Team
NGTSN	Noble Gas and Tritium Surveillance Network (EMSL-LV)
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NLV	North Las Vegas, Nevada
NLVF	North Las Vegas Facility
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPL	National Priority List
NPS	National Park Service
NRACC	Nuclear Radiation Assessment Cross Check Program (EMSL-LV)
NRC	National Response Center
NRD	EMSL-LV Nuclear Radiation Assessment Division
NRDS	Nuclear Rocket Development Station
NRS	Nevada Revised Statutes
NTS	Nevada Test Site
NTSO	DOE Nevada Test Site Operations Office
NVLAP	National Voluntary Laboratory Accreditation Program
offsite	in the immediate area off the NTS
onsite	on the NTS
O&M	Operations and Maintenance
OP	Operating Permit
ORSP	Offsite Radiological Safety Program
PAT	NIOSH Proficiency Analytical Testing Program
PCB	polychorinated biphenyl
PHS	U.S. Public Health Service
PIC	pressurized ion chamber
POTW	Publicly Owned Treatment Works
ppb	parts per billion
ppm	parts per million
PTC	permit to construct
QA	quality assurance
QAP	Quality Assessment Program
QC	quality control
QSG	Quality Support Group
RAM	remote area monitor
RC	residual chlorine
RCRA	Resource Conservation and Recovery Act
R&D	Research and Development
REECo	Reynolds Electrical & Engineering Company, Inc.
RIDP	Radionuclide Inventory and Distribution Program
RI/FS	remedial investigation and feasibility study
RNMS	Radionuclide Migration Study
RPD	relative percent difference
RSD	relative standard deviation
RSL	Remote Sensing Laboratory
RSN	Raytheon Services Nevada
RSTN	Remote Seismic Test Network
RWMS	Radioactive Waste Management Site
s	sample standard deviation
SAM	Sample and Analysis Management System
SARA	Superfund Amendments and Reauthorization Act
SASN	Standby Air Surveillance Network (EMSL-LV)

SBO	Santa Barbara Operations, EG&G/EM
SCARS	System Control and Receiving Station
SDWA	Safe Drinking Water Act
se	standard error of the mean
SEE	specific effective energy
sem	standard error of the mean
SGZ	surface ground zero
SLB	shallow land burial
SLD	shallow land disposal
SMS	Strategic Materials Storage
SMSN	Standby Milk Surveillance Network (EMSL-LV)
SNL	Sandia National Laboratory
SOP	Standard Operating Procedure
STL	Special Technologies Laboratory, EG&G/EM
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TP	TRU Pad
TRU	transuranic
TSCA	Toxic Substances Control Act
TSI	Thermal System Insulation
TSS	total suspended solids
TTR	Tonopah Test Range
UCLA	University of California, Los Angeles
UNLV	University of Nevada, Las Vegas
UOR	Unusual Occurrence Report
URTD	upper respiratory tract disease
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTM	Universal Transmercater
VOC	volatile organic compound
WAMD	Washington Aerial Measurements Department, EG&G/EM
WCO	Woburn Cathode Ray Tube Operations, EG&G/EM
WEB	Waste Examination Building
WHO	World Health Organization
WMD	REECo Waste Management Department
WIPP	Waste Isolation Pilot Plant
WM&PAP	Waste Minimization & Prevention Awareness Plan

1.0 SUMMARY

Stuart C. Black and Alan R. Latham

Monitoring and surveillance on and around the NTS by DOE contractors and Site user organizations during 1991 indicated that underground nuclear testing operations were conducted in compliance with regulations, i.e., the dose the maximally exposed offsite individual could have received was less than 0.09 percent of the guideline for air exposure. All discharges of radioactive liquids remained onsite in containment ponds, and there was no indication of potential migration of radioactivity to the offsite area through groundwater. Surveillance around the NTS indicated that airborne radioactivity from test operations was not detectable offsite, and no measurable net exposure to members of the offsite population was detected through the offsite dosimetry program. Using the CAP88-PC model and NTS radionuclide emissions data, the calculated maximum effective dose equivalent offsite would have been 8.6×10^{-3} mrem. Any person receiving this dose was also exposed to 142 mrem from natural background radiation. There were no nonradiological releases to the offsite area. Hazardous wastes were shipped to EPA-approved disposal facilities. Compliance with the various regulations stemming from the National Environmental Policy Act is being achieved and, where mandated, permits for air and water discharges and waste management have been obtained from the appropriate agencies.

Non-NTS support facilities complied with the requirements of air quality permits and state or local wastewater discharge and hazardous waste permits.

1.1 ENVIRONMENTAL MANAGEMENT

The DOE Nevada Field Office (DOE/NV) is committed to increasing the quality of its management of NTS environmental resources. This has been promoted by the establishment of an Environmental Protection Division and a Health Protection Division within the Office of Environment, Safety, and Health that work with the Environmental Restoration and Waste Management Division to address those environmental issues that arise in the course of performing the primary mission of the DOE/NV, underground testing of nuclear explosive devices. An environmental survey in 1987 and a Tiger Team assessment in 1989 identified numerous issues that must be resolved before DOE/NV can be considered in full compliance with environmental laws and regulations. As of March 31, 1992, 19 of the 105 environmental survey items and 69 of the 149 Tiger Team findings remain open. Some of the remaining items require more time and funding before they can be completed. Progress on corrective actions to bring operations into compliance is reported to DOE Headquarters Environment and Health in a Quarterly Compliance Action Report.

Operational releases of radioactivity are reported soon after their occurrence to the Idaho National Engineering Laboratory through an Unusual Occurrence Report. In compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP), the data from these reports each year are cumulated and used as input to EPA's CAP88-PC software program to calculate

potential annual effective dose equivalents to people living beyond the boundaries of the NTS and the surrounding exclusion areas.

1.2 RADIOLOGICAL ENVIRONMENT

Radiological effluents in the form of air emissions and liquid discharges are released into the environment as a routine part of operations on the NTS. Radioactivity in liquid discharges released to onsite waste treatment or disposal systems (containment ponds) is monitored to assess the efficacy of treatment and control and to provide a quantitative and qualitative annual summary of the radioactivity released onsite. Air emissions are monitored for source characterization and operational safety as well as for environmental surveillance purposes.

Air emissions in 1991 consisted primarily of small amounts of radioactive xenon, krypton, argon, iodine, and tritium released to the atmosphere during:

- Post-test drilling, mining, and/or sampling operations for three 1991 underground nuclear tests
- Continuing seepage of radioactive noble (non-detectable by effluent monitoring in 1991) gases from higher yield (>20 kt) tests that are conducted on Pahute Mesa

There was no "prompt venting" (dynamic release of radioactivity within the first hour following a test) from any of the eight announced underground nuclear tests. Approximately 1.3 curies of radioactivity were released during post-test operations for recovery of drilling cores and other samples from the underground detonation vicinity. Diffuse emission sources included slightly above detectable amounts of HTO from the RWMS in Area 5, $^{239+240}$Pu from the BWMF in Area 3, and ^{85}Kr from Pahute Mesa. Table 1.1 shows the quantities of radionuclides released, including assumed loss of laboratory standards. None of the radioactive materials listed in this table were detected above ambient levels in the offsite area.

Onsite liquid discharges to containment ponds included approximately 1700 curies of tritium. An additional 120 curies were released to the Area 5 Radionuclide Migration Study ditch and pond (see Section 5.1.3 for a complete description) for a total NTS release of approximately 1800 curies to onsite ponds. Evaporation could have contributed tritiated water vapor to the atmosphere, but the amounts were too small to be detected by the tritium monitors offsite. No known liquid effluents were discharged offsite.

1.2.1 OFFSITE MONITORING

The offsite radiological monitoring program is conducted around the NTS by the EPA's Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV), under an Interagency Agreement. This program consists of several extensive environmental sampling, radiation detection, and dosimetry networks.

In 1991 the Air Surveillance Network (ASN) was made up of 33 continuously operating sampling locations surrounding the NTS and 76 standby stations (operated one or two weeks each quarter) in all states west of the Mississippi River. The 33 ASN stations included 19 located at Community Radiation Monitoring Program (CRMP) stations, described below. During 1991 no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from the ASN. Other than naturally occurring ^{7}Be, the only specific radionuclide detected by this network was $^{239+240}$Pu on special high-volume air filter samples from Rachel, Nevada, in June, 1991 and Amargosa Valley in May, 1991.

Table 1.1 Radionuclide Emissions on the NTS - 1991

Radionuclide	Half-life (years)	Quantity Released (Ci)
Airborne Releases		
^{3}H	12.35	[a]0.50
^{37}Ar	0.096	0.45
^{39}Ar	269	2.1×10^{-4}
^{85}Kr	10.72	0.0066
^{131m}Xe	0.0326	0.007
^{133}Xe	0.0144	0.85
^{133m}Xe	0.0071	0.004
^{127}Xe	0.10	6.6×10^{-6}
^{129m}Xe	0.022	5.2×10^{-5}
^{131}I	0.022	[a]1.1×10^{-4}
^{241}Am	458.	[a]8.3×10^{-6}
$^{239+240}Pu$	24065.	[a]6.1×10^{-4}
^{238}Pu	87.74	[a]2.5×10^{-7}
^{137}Cs	30.2	[a]2.6×10^{-7}
Tunnel and Radionuclide Migration Ponds		
^{3}H	12.35	[b]1800
^{238}Pu	87.743	2.7×10^{-5}
$^{239+240}Pu$	24065	2.7×10^{-4}
^{90}Sr	29	5.6×10^{-4}
^{137}Cs	30.17	1.3×10^{-2}
Gross Beta	---	4.1×10^{-2}

a Includes calculated data from air sampling results and/or loss of laboratory standards.
b Assumes total evaporation of all tritiated water effluents.

The Noble Gas and Tritium Surveillance Network (NGTSN) consisted of 21 offsite noble gas samplers and 22 tritium-in-air samplers, three on standby, located outside the NTS and exclusion areas in the states of Nevada, California, and Utah. During 1991 no radioactivity that could be related to NTS activities was detected at any NGTSN sampling station.

As in previous years, results for xenon and tritium were typically below the minimum detectable concentration (MDC). The results for krypton, although exceeding the MDC, were within the range of worldwide values expected from sampling background levels and the range was similar to last year's.

Sampling of Long-Term Hydrological Monitoring Program (LTHMP) wells and surface waters around the NTS showed only background radionuclide concentrations. The LTHMP also included groundwater and surface water monitoring at locations in Alaska, Colorado, Mississippi, New Mexico, and Nevada where underground tests were conducted. The results obtained from analysis of samples collected at those locations were consistent with previous data except for a sample from a deep well at Project GASBUGGY where the tritium concentration appears to be

increasing. No concentrations of radioactivity detected in water, milk, vegetation, soil, fish, or animal samples posed any significant health risk.

The Milk Surveillance Network (MSN) consisted of about 24 sampling locations within 300 kilometers (186 miles) of the NTS and 115 Standby Milk Surveillance Network (SMSN) locations throughout the major milk sheds west of the Mississippi River. Tritium was detected in one SMSN sample. Radiostrontium above the MDC was found in four samples at two different locations in the MSN during the year. Fifteen samples from the SMSN contained detectable ^{90}Sr that was attributed to worldwide fallout. The levels in the SMSN have tended to decrease over time since reaching a maximum in 1964. The results from these networks are consistent with previous data and indicate little or no change.

Other foods were analyzed regularly, most of which were meat from domestic or game animals collected on and around the NTS. The ^{90}Sr levels in samples of animal bone remained very low, as did $^{239+240}Pu$ in both bone and liver samples. Carrots, beets and potatoes from several offsite locations contained normal ^{40}K activity. Small amounts of plutonium found on a few samples were attributed to incomplete washing of soil from the samples. In two instances, tritium in animal blood was unusually high indicating the animals were likely drinking form the Area 12 containment ponds.

External exposure was monitored by a network of thermoluminescent dosimeters (TLDs) at 131 fixed locations surrounding the NTS and by TLDs worn by 72 offsite residents (Figure 4.11 shows the locations). No apparent net exposures were related to NTS activities. The range of exposures measured, varying with altitude and soil constituents, was similar to the range of such exposures found in other areas of the U.S. The median exposure over all stations was 87 mR and for all monitored persons was 76 mR.

Internal exposure was assessed by whole-body counting through use of a single germanium detector, lung counting with six semi-planar detectors, and bioassay through radiochemical procedures. In 1991 counts were made on 350 individuals, of whom 106 were participants in the Offsite Internal Dosimetry Program. In general, the spectra obtained were representative of natural background with only normal ^{40}K being detected. No transuranics were detected in any lung counting data. Physical examination of offsite residents revealed only a normal, healthy population consistent with the age and sex distribution of that population.

No radioactivity attributable to NTS operations was detected by any of the monitoring networks. However, based on the NTS releases reported in Section 5, Table 5.1, atmospheric dispersion model calculations (CAP88-PC) indicated that the maximum effective dose equivalent to any offsite individual would have been 8.6×10^{-3} mrem (8.6×10^{-5} mSv), and the dose to the population within 80 kilometers of the emission sites would have been 4.2×10^{-2} person-rem (4.2×10^{-4} person-Sv). The hypothetical person receiving that dose was also exposed to 142 mrem from natural background radiation. A summary of the effective dose equivalents due to operations at the NTS is presented in Table 1.2.

A network of Community Radiation Monitoring Program (CRMP) stations is operated by local residents. Each station is an integral part of the ASN, NGTSN, and TLD networks. In addition, they are equipped with a pressurized ion chamber (PIC) connected to a gamma-rate recorder. Each station also has satellite telemetry transmitting equipment so that gamma exposure measurements acquired by the PICs are transmitted via the Geostationary Operational Environmental Satellite (GOES) to the NTS and from there to the EMSL-LV by dedicated telephone line. Samples and data from these CRMP stations are analyzed and reported by

EMSL-LV and interpreted and reported by the Desert Research Institute, University of Nevada System. All measurements for 1991 were within the normal background range for the U.S.

Table 1.2 Summary of Effective Dose Equivalents from NTS Operations during 1991

	Maximum EDE at NTS Boundary[a]	Maximum EDE to an Individual[b]	Collective EDE to Population within 80 km of the NTS Sources
Dose	9.4×10^{-3} mrem (9.4×10^{-5} mSv)	$8.6 \pm 0.8 \times 10^{-3}$ mrem (8.6×10^{-5} mSv)	4.2×10^{-2} person-rem (4.2×10^{-4} person-Sv)
Location	Site boundary 42 km WSW of NTS Area 12	Springdale, NV, 56 km WSW of NTS Area 12	21,700 people within 80 km of NTS Sources
NESHAP Standard	10 mrem per year (o.1 mSv per yr)	10 mrem per year (0.1 mSv per year)	-----
Percentage of NESHAP	9.4×10^{-2}	8.6×10^{-2}	-----
Background	142 mrem (1.4 mSv)	142 mrem (1.4 mSv)	1660 person-rem (16.6 person Sv)
Percentage of Background	6.6×10^{-3}	6×10^{-3}	2.5×10^{-3}

(a) The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the NTS boundary located 42 km WSW from the Area 12 tunnel ponds.

(b) The maximum individual dose is to an individual outside the NTS boundary at a residence where the highest dose-rate occurs as calculated by CAP88-PC (Version 1.0) using NTS effluents listed in Table 5.1 and assuming all tritiated water input to containment ponds was evaporated.

1.2.2 ONSITE MONITORING

The onsite environmental surveillance program consists of 52 air sampling stations collecting particulates and reactive gases; 17 samplers collecting atmospheric moisture for tritium analysis; 7 samplers collecting samples for noble gas analysis; 63 water sampling locations that include wells, springs, reservoirs, and ponds onsite; and 187 locations where TLDs are positioned for measurement of external gamma exposures. The locations of these environmental surveillance stations are shown in Chapter 4, Figures 4.1 through 4.4.

Most of the radioactive air effluents on the NTS in 1991 arose from operations related to underground nuclear explosives tests conducted by the Defense Nuclear Agency/Department of Defense; Lawrence Livermore National Laboratory; and Los Alamos National Laboratory.

The primary release mechanisms for these effluents were operational activities such as drill-backs, minebacks, and tunnel purgings. Seepage of noble gases through the soil column to

ground surface was a minor contributor to the measured effluents. The radioactive air effluents summarized in Table 1.1 are described specifically in Section 5, Table 5.2.

Approximately 1800 air samples were analyzed by gamma spectroscopy. Except for four isolated cases, all isotopes detected by gamma spectroscopy were naturally occurring in the environment (^{40}K, ^{7}Be, and members of the uranium and thorium series). Trace amounts of ^{183}Ta, ^{139}Ce, and ^{131}I were seen once each at different locations in Area 5, the weeks of March 4, April 1 and December 16: similarly , a trace amount of ^{144}Ce was seen at Area 11, Gate 293, the week of April 1. Plutonium analyses of monthly composited air filters indicated an annual arithmetic averaged below 10^{-15} µCi/mL (10^{-4} Bq/m^3) of $^{239+240}Pu$ and 10^{-17} µCi/mL (10^{-6} Bq/m^3) of ^{238}Pu for all locations during 1991, with the majority of results for both isotopes being on the order of 10^{-18} µCi/mL (10^{-6} Bq/m^3). A slightly higher average was found in samples from the Bulk Waste Management Facility (BWMF), but that level was calculated to be only 0.01 percent of the Derived Air Concentration. Higher than background levels of plutonium are to be expected in some air samples because atmospheric testing in the 1950s and nuclear safety tests (where chemical explosives were used to blow apart nuclear devices) deposited plutonium on the surface of the NTS.

The annual average concentration of ^{85}Kr from the seven noble gas monitoring stations was 25 x 10^{-12} µCi/mL, which is somewhat less than the average reported by EMSL-LV for the offsite network. This concentration is similar to that reported in previous years and is attributed to worldwide distribution of fallout from the use of nuclear technology. As has been the case in the past, the ^{133}Xe results were below the detection limit except for a few instances when ^{133}Xe seeped through the ground after an underground test.

Throughout the year atmospheric moisture was collected for two-week periods at 17 locations on the NTS and analyzed for tritiated water content (HTO). The annual arithmetic average of (5.1 ± 6.6) x 10^{-6} pCi/mL was similar to last year's average. The locations with the highest concentrations were those near the Radioactive Waste Management Site (RWMS) in Area 5, as would be expected, and at the Area 15 EPA Farm, which probably reflects a contribution from the SEDAN crater.

The primary radioactive liquid discharge to the onsite environment in 1991 was seepage from the test tunnels in Rainier Mesa (Area 12) contributing 270 million liters of water containing approximately 1700 curies of tritium to containment ponds near the tunnels. Water pumped from the well in Area 5 used for the Radionuclide Migration Study (RNMS) amounted to 400 million (4 x 10^{8}) liters containing 120 curies of tritium all of which was discharged to a ditch and all was assumed to have evaporated. Contaminated water discharges to the pond for the Area 6 Decontamination Facility (used for equipment decontamination) contributed 2.0 x 10^{-2} curies of tritium to the pond. All of this tritiated water was also assumed to have evaporated.

Surface water sampling was conducted at 15 open reservoirs, 7 springs, 10 containment ponds, and 3 sewage lagoons. A grab sample was taken each month from each of these surface water sites for analysis of gross beta, tritium, and gamma-emitter concentrations. Each quarter a sample was taken for plutonium analysis, and ^{90}Sr was analyzed once per year.

Water samples from the springs, reservoirs, and lagoons contained background levels of gross beta, tritium, plutonium, and strontium. Samples collected from the tunnel containment ponds and the Area 6 Decontamination Facility pond contained elevated levels of radioactivity as would be expected. Water samples collected from the RNMS well contained tritium at concentrations

exceeding the National Primary Drinking Water Regulation level of 9×10^{-5} µCi/mL (using a DCG from ICRP-30 for 4 mrem EDE), but it was not used for drinking.

Onsite water derived from onsite supply wells and distribution systems was sampled and analyzed monthly for radionuclides. The network average gross beta activity of 8.6×10^{-9} µCi/mL was 3 percent of the Derived Concentration Guide (DCG) for ^{40}K (used for comparison purposes); gross alpha was 6.3×10^{-9} µCi/mL, which was 42 percent of the drinking water standard; ^{90}Sr was 3.0×10^{-12} µCi/mL (1.1×10^{-4} Bq/L) or 0.01 percent of the DCG; ^{3}H concentrations were -3.4×10^{-9} µCi/mL (-0.13 Bq/L) for the potable supply wells and 5.3×10^{-8} µCi/mL (2.0 Bq/L) for the non-potable supply wells with both less than 0.06 percent of the DCG; $^{239+240}Pu$ was 5.0×10^{-12} µCi/mL (1.9×10^{-4} Bq/L) or 0.08 percent of the DCG, and ^{238}Pu with a concentration of 2.0×10^{-11} µCi/mL (7.4×10^{-4} Bq/L) was 0.2 percent of the DCG.

External gamma radiation exposure data from the onsite TLD network indicated the gamma exposure rates recorded during 1991 were not statistically different from the data collected in 1990. Recorded exposure rates ranged from 69 mR/year in Mercury to 3883 mR/year in a contaminated area in Area 5. Average annual exposure rates at NTS boundary TLD stations ranged from 74 to 193 mR/year and the annual average for all onsite "control" stations (considered uncontaminated) was 112 mR/year as compared to last years value of 110 mR/yr.

Ecological studies related to environmental radioactivity on the NTS continued under the Basic Environmental Compliance and Monitoring Program (BECAMP). The studies included investigating the movement of radionuclides on and around the NTS, development of a human dose-assessment model specifically for the NTS, and monitoring of flora and fauna on the NTS to assess changes over time in the ecological condition of the NTS.

BECAMP efforts in 1991 included (1) conducting a characterization study of resuspension processes from a plutonium-contaminated site, (2) preparing final documentation of field monitoring techniques to detect changes in radionuclide concentrations in soil, (3) development of a study plan for *in situ* surveys of water-erosion channels through plutonium-contaminated surface soils, (4) reporting the results of an analysis of the NAEG model for sensitivity of calculated doses to relative variations in levels of radionuclides in soil and for uncertainty in model parameters (Kercher and Anspaugh 1991), (5) completing a paper dealing with the possible differential movement of plutonium isotopes (^{238}Pu versus $^{239+240}Pu$) in the NTS environment, and (6) completing a report on the findings and conclusions from the Radionuclide Inventory and Distribution Program (RIDP, McArthur 1991).

1.2.3 LOW-LEVEL WASTE DISPOSAL

Environmental monitoring at and around the low-level Area 5 RWMS and Area 3 BWMF indicated that radioactivity was just detectable at the site boundaries but not away from the waste management site areas. This monitoring included air sampling, water sampling, tritium migration studies, and vadose zone monitoring for hazardous constituents.

An unsaturated zone (vadose zone) sampling system has been installed as a method of detecting any downward migration of radioactive waste.

1.3 NONRADIOLOGICAL MONITORING

Nonradiological environmental monitoring of NTS operations involved only onsite monitoring because there were no nonradiological hazardous material discharges offsite. The primary environmental permit areas for the NTS were monitored to verify compliance with air quality and the Resource Conservation and Recovery Act (RCRA) requirements. Air emissions sources common to the NTS included particulates from construction, aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. These emissions were covered by a series of 38 air quality permits from the state of Nevada. The only nonradiological air emission of regulatory concern under the Clean Air Act was asbestos removal during building renovation projects and from insulated piping at various locations onsite. These were reported to the EPA under NESHAP requirements.

RCRA-required monitoring included waste management and environmental compliance activities that necessitated the analysis of soil, water, sediment and oil samples. Low levels of targeted chemicals were found in several samples.

As there are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works, no Clean Water Act National Pollution Discharge Elimination System permits were required for NTS operations. Under the conditions of state of Nevada operating permits, liquid discharges to 13 onsite sewage lagoons are regularly tested for biochemical oxygen demand, pH, and total suspended solids. In addition to the state-required monitoring, these influents were also tested for RCRA-related constituents as an internal initiative to further protect the NTS environment.

In compliance with the Safe Drinking Water Act and five state of Nevada drinking water supply system permits for onsite distribution systems supplied by onsite wells, drinking water systems are sampled monthly for residual chlorine, Ph, bacteria, and, less frequently, for other water quality parameters. Federal and state standards were slightly exceeded in five wells for fluorides, nitrates, pH, and dissolved solids. In the case of fluorides, the state granted a variance to exceed Secondary fluoride standards as long as Primary standards were met. For the other exceedances, the state has been contacted to assist in developing a mitigation plan.

Monitoring for polychlorinated biphenols as required by the Toxic Substances Control Act involved analysis of 184 samples. Only one of the samples exceeded 500 ppm.

At the Liquified Gaseous Fuels Spill Test Facility, 17 planned spill tests using hydrofluoric acid (HF) were conducted during 1991. None of the tests generated enough HF to be detected at the NTS boundary during or after the tests.

Monitoring of flora and fauna populations on the NTS in control and disturbed areas indicated that the extended drought conditions that affected the Western U.S. had more effect on those populations than any human activity. This was also true for flora and fauna on a previously studied plot downwind of the Liquified Gaseous Fuels Spill Test Facility.

1.4 COMPLIANCE ACTIVITIES

Besides conducting the nuclear explosives testing program in compliance with the various radiation protection standards and guides as issued by the International Commission on Radiological Protection and national authorities, DOE/NV is required to comply with various

environmental protection acts and regulations. Monitoring activities required for compliance with the Clean Air Act, Clean Water Act, Safe Drinking Water Act, Toxic Substances Control Act, and RCRA are summarized above. Also, National Environmental Policy Act activities included preparation of four Environmental Assessments currently in various stages of processing, and 48 Categorical Exclusions.

Wastewater discharges on the NTS are not regulated under National Pollutant Discharge Elimination System permits because all such discharges are to onsite sewage lagoons. Wastewater discharges from the non-NTS support facilities of EG&G Energy Measurements, Inc. were predominantly under the regulated levels established by city or county publicly owned treatment works. One notice of violation was issued to EG&G/EM, Santa Barbara Operations which was the direct result of work contracted by the facility landlord.

Twenty-four underground storage tanks that contained, or had contained, petroleum products were either removed, closed in place, or temporarily closed. Additionally, seventeen tanks were temporarily closed in 1991 while awaiting upgrades.

In 1991, 17 pre-activity surveys, required by the Archeological and Cultural History Preservation Act, were conducted for archaeological sites on the NTS, and reports on the findings were prepared. These pre-activity surveys identified 56 sites containing previously unknown archaeological information. These sites were added to the cultural resources inventory files and site records, and all artifacts collected from the NTS were processed for storage. Due to avoidance of all potentially significant sites by activities at the NTS, no test excavations, data-recovery plans or data-recovery projects were undertaken in 1991

1.5 GROUNDWATER PROTECTION

DOE/NV instituted a Long-Term Hydrological Monitoring Program (LTHMP) in 1972 to be operated by the EPA under an Interagency Agreement. Groundwater was monitored on and around the NTS, at eight sites in other states, and at two off-NTS locations in Nevada in 1991 to detect the presence of any radioactivity that may be related to nuclear testing activities. No radioactivity was detected in the groundwater sampling network around the NTS. Tritium escaped in 1965 from the LONG SHOT test on Amchitka Island and contaminated surficial groundwater, and, during cleanup and disposal operations, shallow groundwater at the Tatum Dome Test Site in Mississippi was contaminated by tritium. The levels at both these sites are decreasing and were well below the National Primary Drinking Water Regulation levels during 1991. NTS supply wells were monitored for gross alpha and beta activity as well as for tritium levels.

Because wells that were drilled for water supply or exploratory purposes are used in the present monitoring program rather than wells drilled specifically for groundwater monitoring, an extensive program of well drilling for groundwater characterization has been started. The design of the program is for installation of approximately 90 wells at strategic locations on and near the NTS. One of these special wells was completed in 1991.

Other activities in this program included studies of groundwater transport of contaminants (radionuclide migration studies) and nonradiological monitoring for water quality assessment and Resource Conservation and Recovery Act requirements.

1.6 RADIOACTIVE AND MIXED WASTE DISPOSAL

Two radioactive waste disposal facilities are operated on the NTS; the Area 5 Radioactive Waste Management Site (RWMS) and the Area 3 Bulk Waste Management Facility (BWMF). During 1991 the RWMS received low-level waste generated at the NTS and other DOE facilities. Waste is disposed of in shallow pits, trenches, and in deep, large-diameter augured shafts. Transuranic (TRU) wastes are stored on a curbed asphalt pad on pallets in 55 gallon drums and various assorted steel boxes pending shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico. The Area 3 BWMF is used for disposal of low-level waste that cannot be packaged for disposal at the Area 5 RWMS.

Environmental monitoring included air sampling, water sampling, tritium migration studies, external gamma exposure and vadose zone monitoring for hazardous constituents. Environmental monitoring results for 1991 indicated that measurable radioactivity from waste disposal operations was detectable only in the immediate area of the facilities.

Resource Conservation and Recovery Act (RCRA) hazardous waste disposal operations at the NTS require the shipment of nonradioactive hazardous materials to licensed disposal facilities offsite. No disposal of hazardous materials was performed at the NTS except as constituents of the Rocky Flats Plant mixed waste received from December 1988 through May 1990.

A Mixed Waste Management Unit (MWMU) is located just north of the RWMS and will be part of routine disposal operations. This area, covering approximately 10 hectares (25 acres), will contain 18 landfill cells to be used for mixed waste disposal. In May 1990 mixed waste disposal operations ceased due to EPA issuance of the Land Disposal Restrictions of RCRA for the Third Thirds Wastes. Active mixed waste disposal operations at the NTS will commence upon completion of a National Environmental Policy Act (NEPA) documentation and issuance of a state of Nevada Part B Permit.

Mixed waste and low-level waste will only be accepted for disposal from generators (onsite and offsite) that have submitted a waste application as required by NVO-325, Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements; that have verified compliance to NVO-325; and that have received DOE/NV approval of the waste stream(s) for disposal at NTS.

1.7 QUALITY ASSURANCE

The quality assurance (QA) program covering NTS activities has three components. There are QA programs for nonradiological analyses, for onsite radiological analyses, and for offsite radiological analyses conducted by EMSL-LV.

1.7.1 ONSITE NONRADIOLOGICAL QUALITY ASSURANCE

The onsite nonradiological quality assurance (QA) program included sample acceptance and control criteria, quality control (QC) procedures, and interlaboratory comparisons through participation in the National Institute of Occupational Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program, the American Industrial Hygiene Association (AIHA) Asbestos Analysts Registry (AAR) Program, the AIHA Bulk Asbestos Analysis Program, National Voluntary Laboratory Accreditation Program (NVLAP) Bulk Asbestos Fiber Analysis Program, and the College of American Pathologists (CAP) Analysis of Lead in Blood Program. Proficiency testing through participation in the EPA Contract Laboratory Program (CLP) was continued.

1.7.2 ONSITE RADIOLOGICAL QUALITY ASSURANCE

The onsite radiological quality assurance (QA) program includes conformance to best laboratory practice. The external quality assurance intercomparison program for radiological data quality assurance consists of participation in the DOE Quality Assessment Program (QAP) administered by the DOE Environmental Measurements Laboratory (EML); the Nuclear Radiation Assessment and Cross Check Program (NRACC) conducted by the EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV); and the quality assessment program sponsored by the International Reference Center for Radioactivity (IRCR) of the World Health Organization (WHO).

1.7.3 OFFSITE RADIOLOGICAL QUALITY ASSURANCE

The policy of the U.S. Environmental Protection Agency (EPA) requires participation in a centrally managed quality assurance program (QA) by all EPA organizational units involved in environmental data collection. The QA program developed by the Nuclear Radiation Assessment Division (NRD) of the Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV) for the Offsite Radiological Safety Program (ORSP) meets all requirements of EPA policy, and also includes applicable elements of the Department of Energy (DOE) QA requirements and regulations. The ORSP QA program defines data quality objectives (DQOs), which are statements of the quality of data a decision maker needs to ensure that a decision based on that data is defensible. Achieved data quality may then be evaluated against these DQOs.

1.8 ISSUES AND ACCOMPLISHMENTS

Principal compliance problems this year were:

- A Notice of Violation was issued for the portable storage bins operating at the Area 12 Batch Plant. Emissions from the bins during the inspection approached 100 percent opacity at times. As required by the state, a new dust collection system was installed for the portable bins. In January 1992, state inspectors observed and approved the new system during its operation. Visible emissions were well below 20 percent. A final report is being prepared to submit to the state through DOE.

- A Notice and Finding of Alleged Violation was issued by the state of Nevada to the Department of Energy and the Defense Nuclear Agency for violation of NRS Chapter 445.221 and NAC Chapter 445.179. The violation involves the modification of tunnel wastewater ponds at U12n Tunnel and the lack of a discharge permit for the same ponds. Response to the alleged violation must be made on or before April 20, 1992.

- A Finding of Alleged Violation and Order was issued by the state of Nevada on March 31, 1992. The Finding and Order relate to the Department of Energy's and Reynolds Electrical & Engineering Co., Inc.'s failure to comply with NRS 459.515 and NAC 444.8632. The violation centered around 11 drums of soil which had been inspected by the state on January 22, 1992. The drummed soil represented drill cuttings in which laboratory analyses indicated the presence of small amounts (parts per billion) of methylene chloride and toluene. The drill cuttings were accumulated in August 1991. Laboratory results were evaluated and a request to dispose of the drums was made in September 1991. On October 4, 1991 DOE/NV and the REECo Waste Management Department (WMD), agreed to leave the drums in place until a decision involving their deposition could be made. On March 17, 1992, DOE/NV instructed WMD to move the

drums to the Area 3 CNC-11, a temporary waste storage area. After further review of the data the REECo Environmental Compliance Office and the WMD determined that the drums contained non-regulated waste. On March 28, 1992, it was recommended to DOE/NV that the drums be sent to U10c Sanitary Landfill for disposal.

- A Finding of Alleged Violation was issued by the state in November 1990 for operation of the TRU pad without interim status. Despite attempts to comply with state requirements, the order to remove the TRU waste was reiterated. An out-of-court solution to this problem is being negotiated.

- The Amador Valley Operations, EG&G/EM, was required to file air permit applications for existing solvent cleaning operations in 1991 to comply with newly issued local regulations.

Some of the accomplishments for 1991 include:

- REECo, at state request, assisted in the cleanup of abandoned hazardous waste in Pahrump, Nevada. Cleanup was completed, the waste transferred to and disposed of by approved hazardous waste disposal firms, and a final report submitted to DOE in June, 1991 for transmittal to the state of Nevada.

- Final versions of the literature review of baseline documents about Native American concerns on the NTS, and of a study plan on how DOE/NV is considering the effects of NTS operations on those concerns were completed as required by the American Indian Religious Freedom Act (AIRFA).

- All REECo NTS waste minimization goals and schedules were met with hazardous waste generation being reduced seven percent over 1990 and over 45 percent compared to 1989. Total solid waste was reduced from 1990-1991 by nine percent.

- An Operations & Maintenance Manual for NTS sewage lagoon systems was approved by the state in March 1992.

- Closed loop steam cleaning, paint thinner recycling, and oil filter crushing technologies were introduced at NTS to further reduce waste.

Of the 149 Tiger Team findings from their 1989 assessment, as of April 1, 1992, 80 of them have been closed in accordance with the DOE/NV Procedure for Closure of Nevada Operations Office (NV) Action Plan, Revision No.0, 07/13/90. Work continues on the remaining 69.

The environmental monitoring results presented in this report document that the 1991 nuclear test operations were conducted with no detectable radiation exposure to the offsite public. Calculation of the highest individual dose that could have been received by an offsite resident (based on onsite measurement of radioactive releases to the atmosphere) equated to 0.0086 mrem to a person living in Springdale, Nevada. This may be compared to that individual's exposure to 142 mrem from natural background radiation.

There were no major incidents of nonradiological contaminant releases to the environment, and ever more intensive efforts to continue characterizing and protecting the NTS environment implemented in 1990 were continued in 1991.

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2.0 INTRODUCTION

Stuart C. Black, H. Bruce Gillen, and Alan R. Latham

The NTS, located in Southern Nevada, has been the primary location for testing of nuclear explosives in the continental U.S. since 1951. Historical testing has included (1) atmospheric testing in the 1950s and early 1960s, (2) underground testing in drilled, vertical holes and horizontal tunnels, (3) earth-cratering experiments, and (4) open-air nuclear reactor and engine testing. During 1991 DOE/NV announced that eight underground nuclear tests were conducted at the NTS. Limited non-nuclear testing included controlled spills of hazardous material at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF). Radioactive and mixed waste disposal facilities for U.S. defense waste were also operated on the NTS.

The NTS environment is characterized by desert valley and Great Basin mountain terrain and topography, with a climate, flora, and fauna typical of the Great Basin deserts of the southwest. Restricted access and extended wind transport times are notable features of the remote location of the NTS and adjacent U.S. Air Force lands. Also characteristic of this area are the great depths to slow-moving groundwaters and little or no surface water. These features afford protection to the inhabitants of the surrounding area from potential radiation exposures as a result of releases of radioactivity or other contaminants from nuclear testing operations. Population density within 150 kilometers of the NTS is only 0.5 persons per square kilometer versus approximately 29 persons per square kilometer in the 48 contiguous states. The predominant land use surrounding the NTS is open range used for livestock grazing with scattered mining and recreational areas.

In addition to the NTS, DOE/NV is responsible for nine non-NTS facilities operated by EG&G Energy Measurements, Inc. (EG&G/EM), in eight different cities. These facilities support the DOE/NV test program in activities ranging from aerial measurements and aircraft maintenance to electronics and heavy industrial fabrication. All of these facilities are located in metropolitan areas.

The EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV), conducts hydrological studies at eight formerly used U.S. nuclear testing locations off the NTS. No tests were conducted at these sites in 1991.

2.1 NTS OPERATIONS

2.1.1 NTS DESCRIPTION

The NTS is operated by the DOE as the on-continent test site for nuclear weapons testing. It is located in Nye County, Nevada, with the southeast corner lying about 56 miles (90 kilometers) northwest of the city of Las Vegas, Nevada, as shown in Figure 2.1. (This figure and other figures in this chapter were generated with a computer-based geographical information system [GIS]. GIS-generated graphics in this report were prepared by EG&G Energy Measurements, Inc., Las Vegas, Nevada.) The NTS encompasses about 3500 square kilometers (1350 square miles), an area larger than the state of Rhode Island. The dimensions of the NTS vary from 46 to 56 kilometers (28 to 35 miles) in width (eastern to western border) and from 64 to 88 kilometers (40 to 55 miles) in length (northern to southern border). The NTS is surrounded on the east, north, and west sides by public access exclusion areas consisting of the Nellis Air Force Base (NAFB) Bombing and Gunnery Range and the Tonopah Test Range. These two areas comprise the NAFB Range Complex, which provides a buffer zone between the test areas and public lands. This buffer area varies from 24 to 104 kilometers (15 to 65 miles) between the test areas and public lands. The combination of the NAFB Range Complex and the NTS is one of the larger unpopulated land areas in the U.S., comprising some 14,200 square kilometers (5470 square miles). Figure 2.2 shows the general layout of the NTS, including the location of major facilities and area numbers referred to in this report. The shaded areas in Figure 2.2 indicate the principal geographical areas used for underground nuclear testing over the history of NTS operations. Mercury, Nevada, at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the Site. Area 12 Base Camp, at the northern end of the Site, is the other major worker housing and operations support facility.

2.1.2 MISSION AND NATURE OF OPERATIONS

The NTS has been the primary location for testing the nation's nuclear explosive devices since January 1951. Tests conducted through the 1950s were predominantly atmospheric tests. These tests involved a nuclear explosive device detonated while on the ground surface, on a steel tower, suspended from tethered balloons, or dropped from an aircraft. Several of the tests were non-nuclear, i.e., "safety" tests, involving destruction of a nuclear device with non-nuclear explosives. Safety tests resulted in dispersion of plutonium in the test vicinity. One of these test areas lies just north of the NTS boundary on the NAFB Range Complex (see Figure 2.3). All announced tests are listed in DOE/NV report NVO-209 (1991).

Underground nuclear tests were first conducted in 1957. Testing was discontinued during a moratorium from October 1958 through September 1961. Four small atmospheric (surface) tests were conducted in 1961 and 1962 following the resumption of underground and atmospheric testing. Two additional safety test series were conducted in the mid-1960s, one on the NAFB Bombing and Gunnery Range and one on the Tonopah Test Range. Since late 1962 nearly all tests have been conducted in sealed (1) vertical shafts drilled into the valley floor of Yucca Flat and the top of Pahute Mesa or (2) horizontal tunnels mined into the face of Rainier Mesa. Six earth-cratering (shallow-burial) tests were conducted over the period of 1962 through 1968 as part of the Plowshare Program, which explored peaceful uses of nuclear explosives. Five of these were in the northwestern quadrant of the NTS. The sixth and largest (SEDAN) was detonated at the northern end of Yucca Flat.

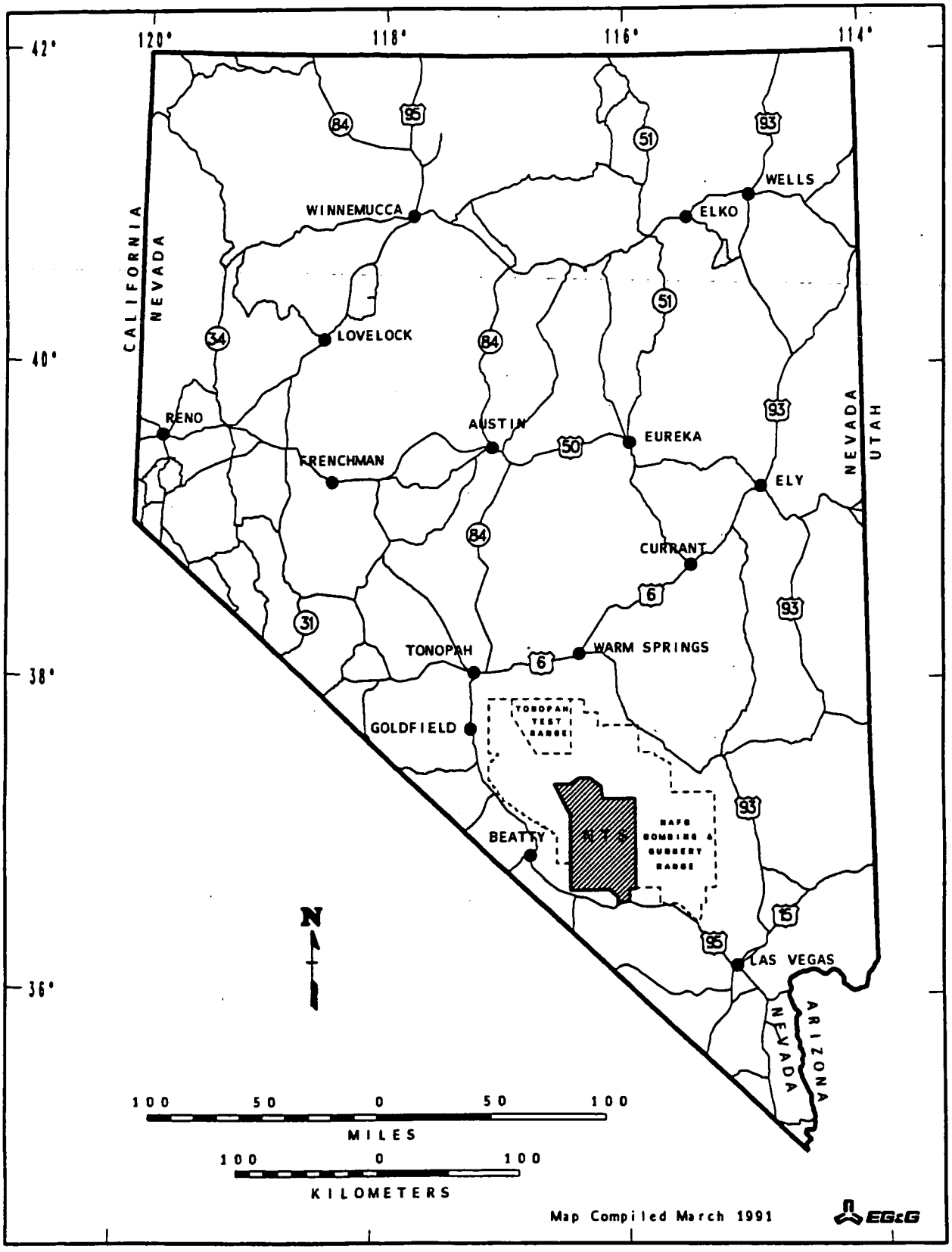

Figure 2.1 NTS Location

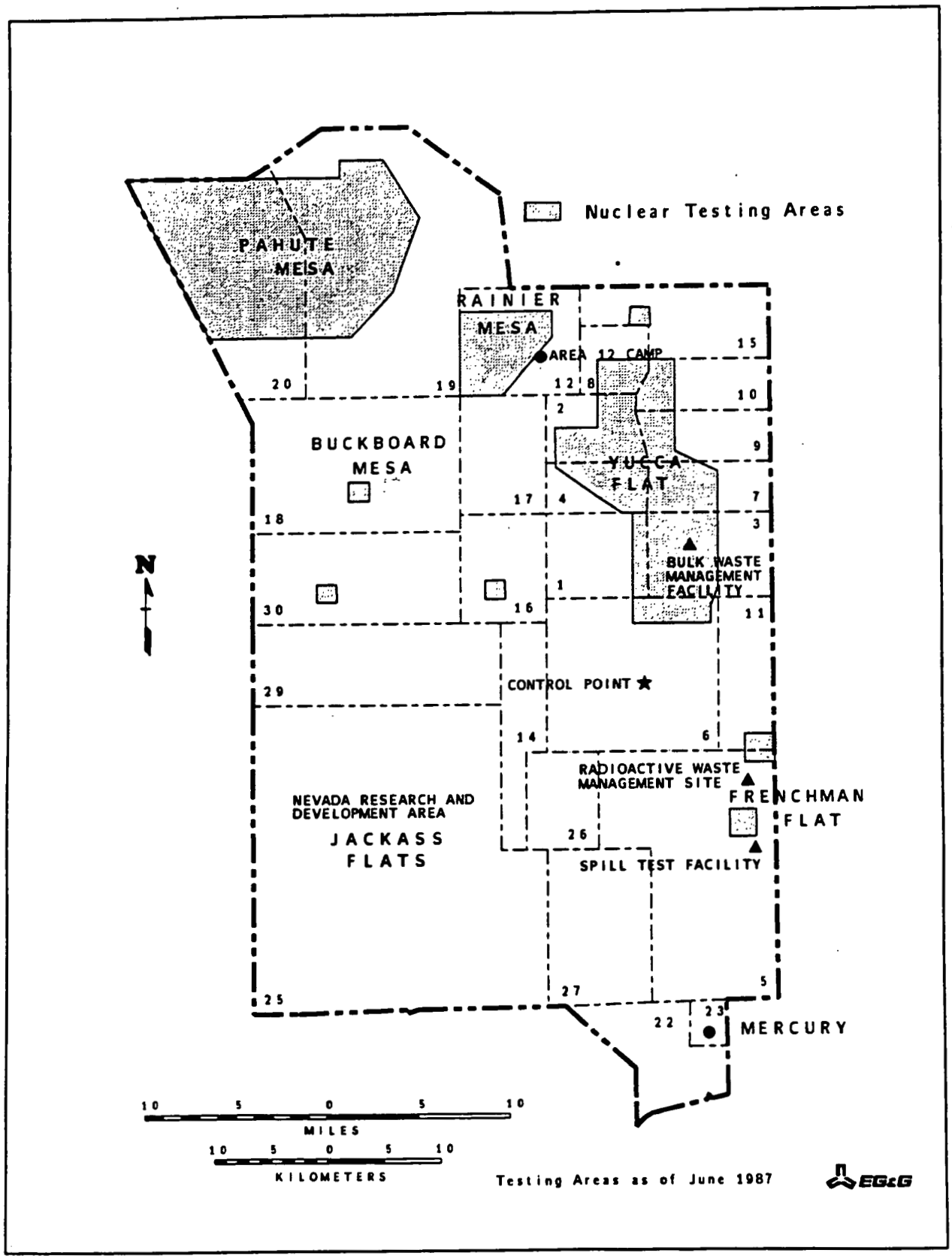

Figure 2.2 NTS Area Designations, Principal Facilities, and Testing Areas

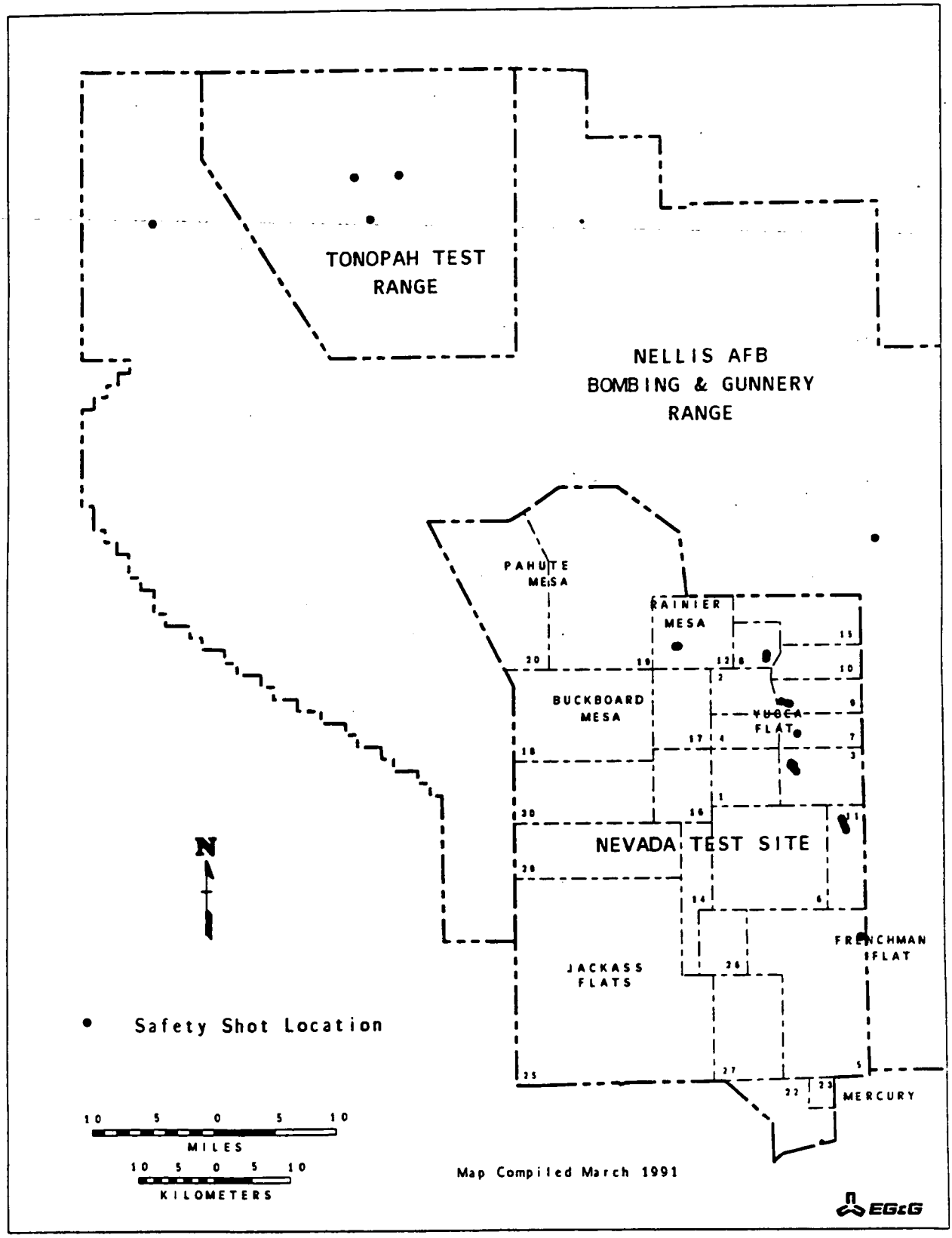

Figure 2.3 Location of Safety Shots in the NAFB Range Complex

Other nuclear testing over the history of the NTS has included the Bare Reactor Experiment - Nevada series of experiments in the 1960s. These tests were performed with a 14-MeV neutron generator mounted on a 465 m (1530 ft) steel tower used to conduct neutron and gamma-ray interaction studies on shielding materials, electronic components, live organisms, and tissue-equivalent simulations for biomedical and environmental research. From 1959 through 1973 a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests were conducted in Area 25 at the Nuclear Rocket Development Station (now the Nevada Research and Development Area). Another series of tests with a nuclear ramjet engine was conducted in Area 26 by the Lawrence Livermore National Laboratory, Livermore, California (LLNL).

Limited non-nuclear testing has also occurred at the NTS, including spills of hazardous materials at the LGFSTF in Area 5. These tests, conducted from the latter half of the 1980s to date, involved controlled spilling of liquid materials to study both spill control and mitigation measures and dispersion and transport of airborne clouds resulting from these spills. These tests are cooperative studies involving private industry, the U.S. Department of Transportation (DOT), and the DOE.

Waste disposal facilities for radioactive and mixed waste are also available at the NTS for DOE defense waste disposal. Disposal sites are located in Areas 3 and 5. At the Area 5 Radioactive Waste Management Site (RWMS), low-level radioactive waste from DOE-affiliated onsite and offsite generators and mixed waste from one offsite generator (Rocky Flats) are disposed of using standard shallow land disposal techniques. The Greater Confinement Disposal facility, consisting of a 3 m (10 ft) diameter shaft 37.5 m (120 ft) deep, is located at the Area 5 RWMS. This facility is used for experimental disposal of wastes not suited for shallow land burial because of high specific activity or because of a potential for migration into biopathways.

Transuranic wastes are retrievably stored in surface containers at the Area 5 RWMS pending shipment to the Waste Isolation Pilot Plant facility in New Mexico. Nonradioactive hazardous wastes are also accumulated at the Area 5 RWMS before shipment to an offsite disposal facility. At the Area 3 Bulk Waste Management Site, only low-level radioactive waste in bulk form (such as debris collected from atmospheric nuclear test locations) is emplaced and buried in surface subsidence craters (formed as a result of underground nuclear tests).

2.1.3 1991 TEST ACTIVITIES

2.1.3.1 NUCLEAR TESTS

The underground nuclear tests conducted during 1991 (the period covered by this annual NTS environmental report) were designed and conducted by two national laboratories and the Defense Nuclear Agency (DNA). The Los Alamos National Laboratory (LANL) of Los Alamos, New Mexico, and LLNL conducted tests in support of DOE nuclear testing program objectives. Sandia National Laboratories (SNL) of Albuquerque, New Mexico, supported tests conducted by the DNA, which uses the NTS as a nuclear testing facility under an agreement with the DOE.

The DOE announced eight underground nuclear tests at the NTS during 1991. A list of these tests is provided in Table 2.1. (A summary of the environmental monitoring observations for each of these tests is provided in Section 5, Table 5.2.)

Table 2.1 Announced Underground Nuclear Tests at the NTS - 1991

Test Name	Date	Testing Organization
COSO	03/08/91	LLNL
BEXAR	04/04/91	LANL
MONTELLO	04/16/91	LLNL
FLOYDADA	08/15/91	LANL
HOYA	09/14/91	LLNL
DISTANT ZENITH	09/19/91	DNA/LANL
LUBBOCK	10/18/91	LANL
BRISTOL	11/26/91	LLNL

Underground testing is carefully designed to ensure containment of the explosive energy and radioactivity resulting from each nuclear explosion. After the nuclear device and related diagnostic equipment are lowered into the prepared vertical shaft or emplaced in the excavated tunnel, the hole or tunnel is closed with a containment system. Vertical holes are back-filled with sand and gravel, and three to six solid plugs are spaced throughout (referred to as "stemming") to enhance containment capabilities. Stemming, including the plugs, forms a seal against leakage of gases to the atmosphere. The stemming material in tunnel tests normally consists of rock-matching grout emplaced close to the device and backed up by varying types, amounts, and combinations of grout and other stemming materials. Some tests may include a "line-of-sight" pipe with mechanical closure systems in the pipe to contain radioactivity. In addition, several large concrete and steel plugs block the tunnel between the experimental area and the portal to afford added protection against the possibility of gas escaping from the stemmed area.

During and following each test, both onsite and offsite monitoring are conducted to document radioactivity that might be released to the atmosphere. Releases might occur immediately following a test as a result of dynamic release (called a "venting" or "prompt" release) of material through cracks, fissures, or the containment system. During later hours, days, or weeks, a release may also occur as a result of slow transfer of gases (seepage) through the soil and rock overburden or through controlled releases as part of post-test diagnostic and sampling operations. The onsite effluent detection and monitoring systems, onsite and offsite environmental surveillance systems, and 1991 results from these monitoring efforts are described in this report.

2.1.3.2 LIQUIFIED GASEOUS FUELS SPILL TEST FACILITY

A total of 17 spill tests were conducted at the LGFSTF in Area 5 of the NTS. (Monitoring results of these tests are shown in Section 7.) The LGFSTF is maintained by EG&G, Inc., and is the basic research tool for studying the dynamics of accidental releases of various hazardous materials. Discharges from the LGFSTF occur at a controlled rate and consist of a measured volume of hazardous test fluid released on a surface especially prepared to meet the test requirements. LGFSTF personnel monitor and record operating data, close-in and

downwind meteorological data, and downwind gaseous concentration levels. Calculation of the potential path of the test effluent is used to help control the test and monitor the data, which is done from a remote location. Spills involving hydrofluoric acid were conducted in 1991 and the results monitored.

An array of diagnostic sensors may be placed up to 16 kilometers downwind of the spill point to obtain cloud-dispersion data. Deployment of the array is test dependent and is not used for all experiments. The array can consist of up to 20 meteorological stations to gather wind speed and wind direction data and up to 41 sensor stations to gather data from a variety of sensors at various levels above ground. The array and associated data-acquisition system are linked to the LGFSTF control point by means of telemetry. The operation and performance of the LGFSTF are controlled and monitored from the Command Control and Data Acquisition System building located one mile from the test fluid spill area.

2.1.4 TOPOGRAPHY AND TERRAIN

The topography of the NTS is typical of much of the Basin and Range physiographic province of Nevada, Arizona, and Utah. North-south-trending mountain ranges are separated by broad, flat-floored, and gently-sloped valleys. The topography is depicted in Figure 2.4. Elevations range from about 910 m (3000 ft) above mean sea level (MSL) in the south and east, rising to 2100 m (6900 ft) in the mesa areas toward the northern and western boundaries. The slopes on the upland surfaces are steep and dissected, whereas the slopes on the lower surfaces are gentle and alluviated with rock debris from the adjacent highlands.

The principal effect upon the terrain from nuclear testing has been the creation of numerous dish-shaped surface subsidence craters, particularly in Yucca Flat. Most underground nuclear tests conducted in vertical shafts produced surface subsidence craters created when the overburden above a nuclear cavity collapsed and formed a rubble "chimney" to the surface (Figure 2.5). A few craters have been formed as a result of tests conducted on or near the surface during atmospheric testing, by shallow depth-of-burial cratering experiments, or following tunnel events.

There are no continuously flowing streams on the NTS. Surface drainages for the Yucca Flat and Frenchman Flat are in closed-basin systems, which drain onto the dry lake beds (playas) in each valley. The remaining area of the NTS drains via arroyos and dry stream beds that carry water only during unusually intense or persistent storms. Rainfall or snow melt typically infiltrates quickly into the moisture-deficient soil or runs off in normally dry channels, where it evaporates or seeps into permeable sands and gravels. During extreme conditions, flash floods may occur. The surface drainage channel pattern for the NTS and its immediate vicinity is displayed in Figure 2.6. The northwest portion (Pahute Mesa) of the NTS has integrated channel systems which carry runoff beyond NTS boundaries into the closed basins and playas in Kawich Valley and Gold Flat on the NAFB Range Complex. The western half and southernmost part of the NTS have channel systems which carry runoff from intense storms towards the southern boundary of the NTS and offsite towards the Amargosa Desert.

2.1.5 GEOLOGY

The basic lithologic structure of the NTS is depicted in Figure 2.7. Investigations of the geology of the NTS, including detailed studies of numerous drill holes and tunnels, have been in progress by the U.S. Geological Survey and other organizations since 1951. As a result

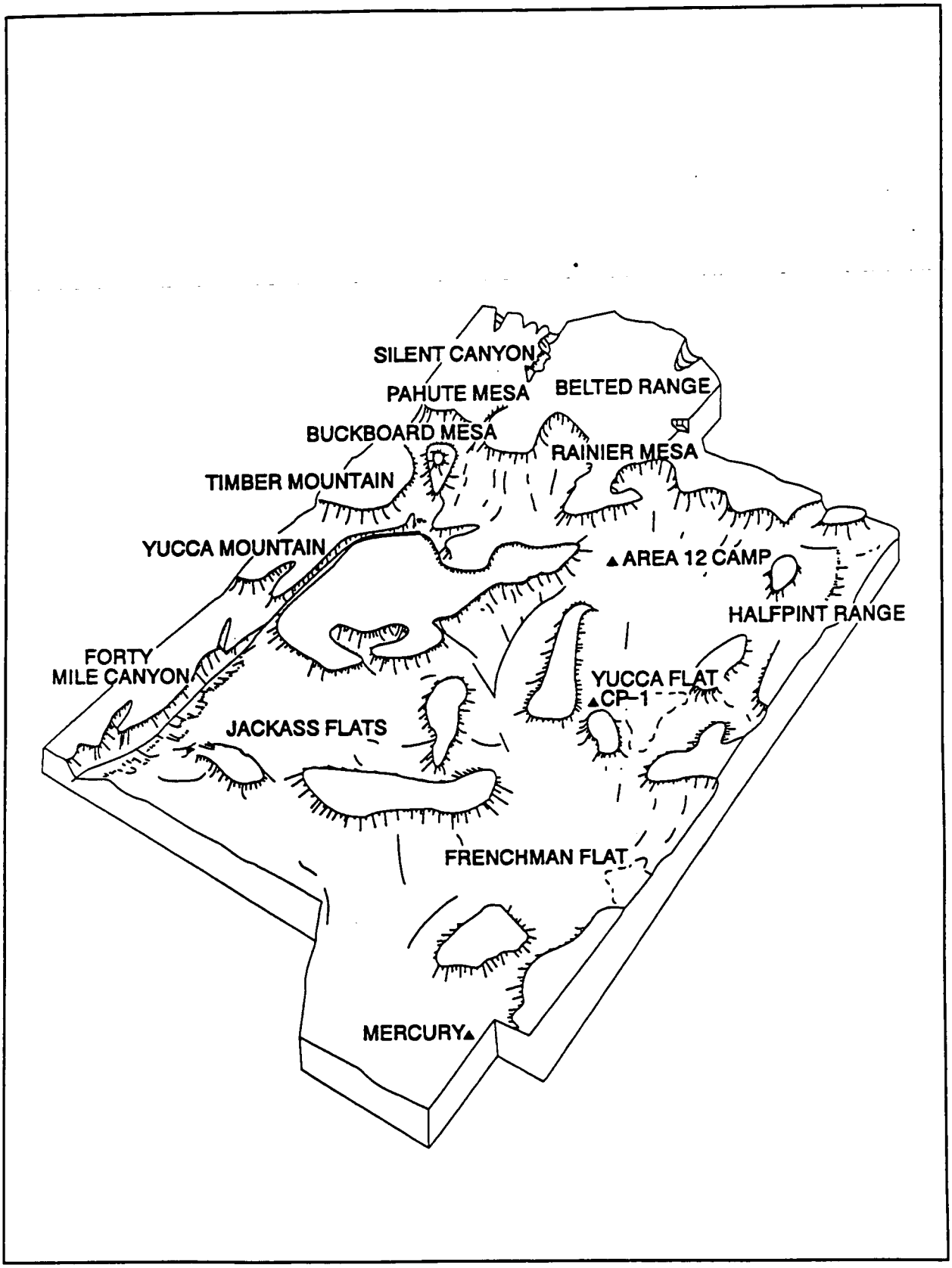

Figure 2.4 Topography of the NTS

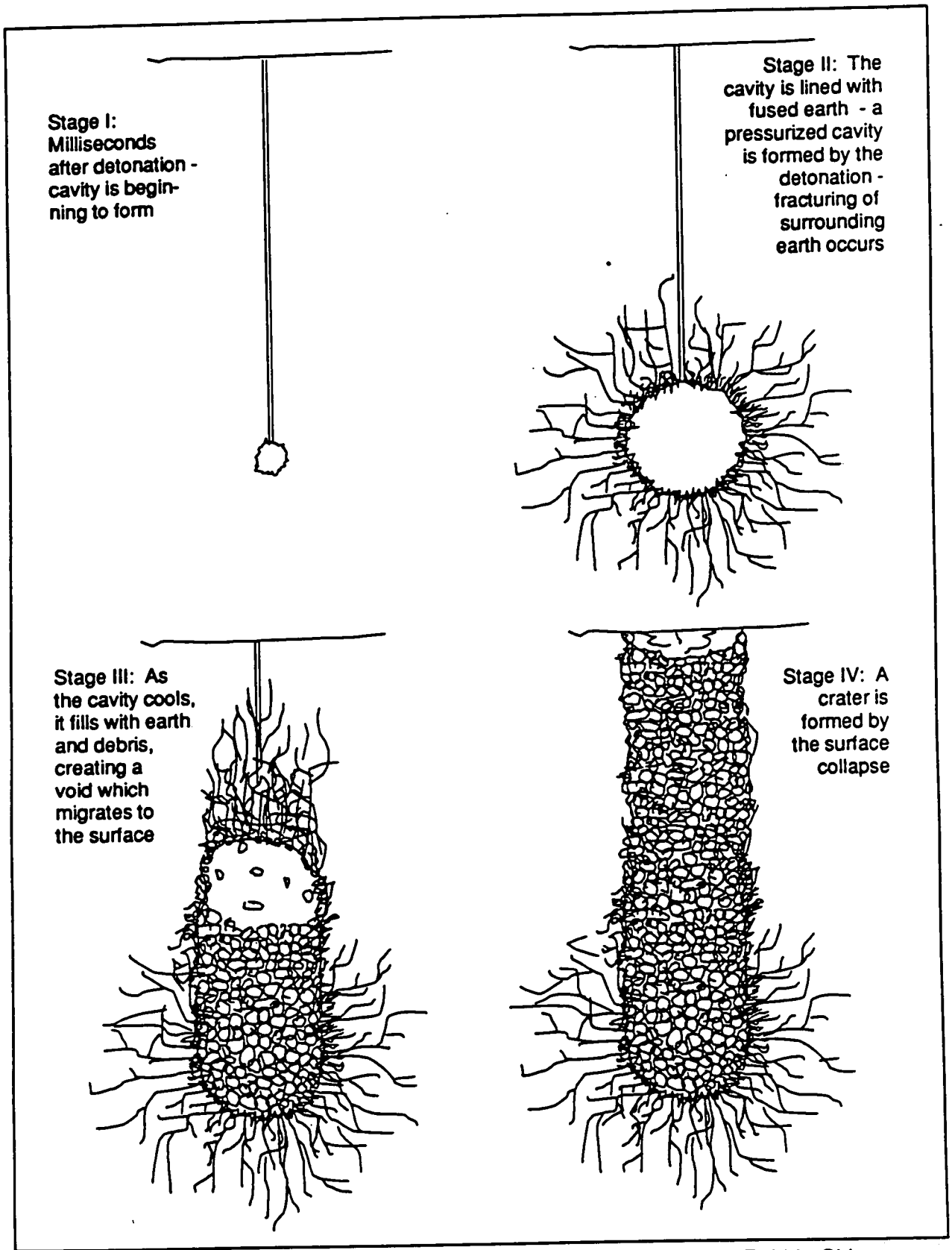

Figure 2.5 Formation of an Underground Nuclear Explosive Test Cavity, Rubble Chimney, and Surface Subsidence Crater

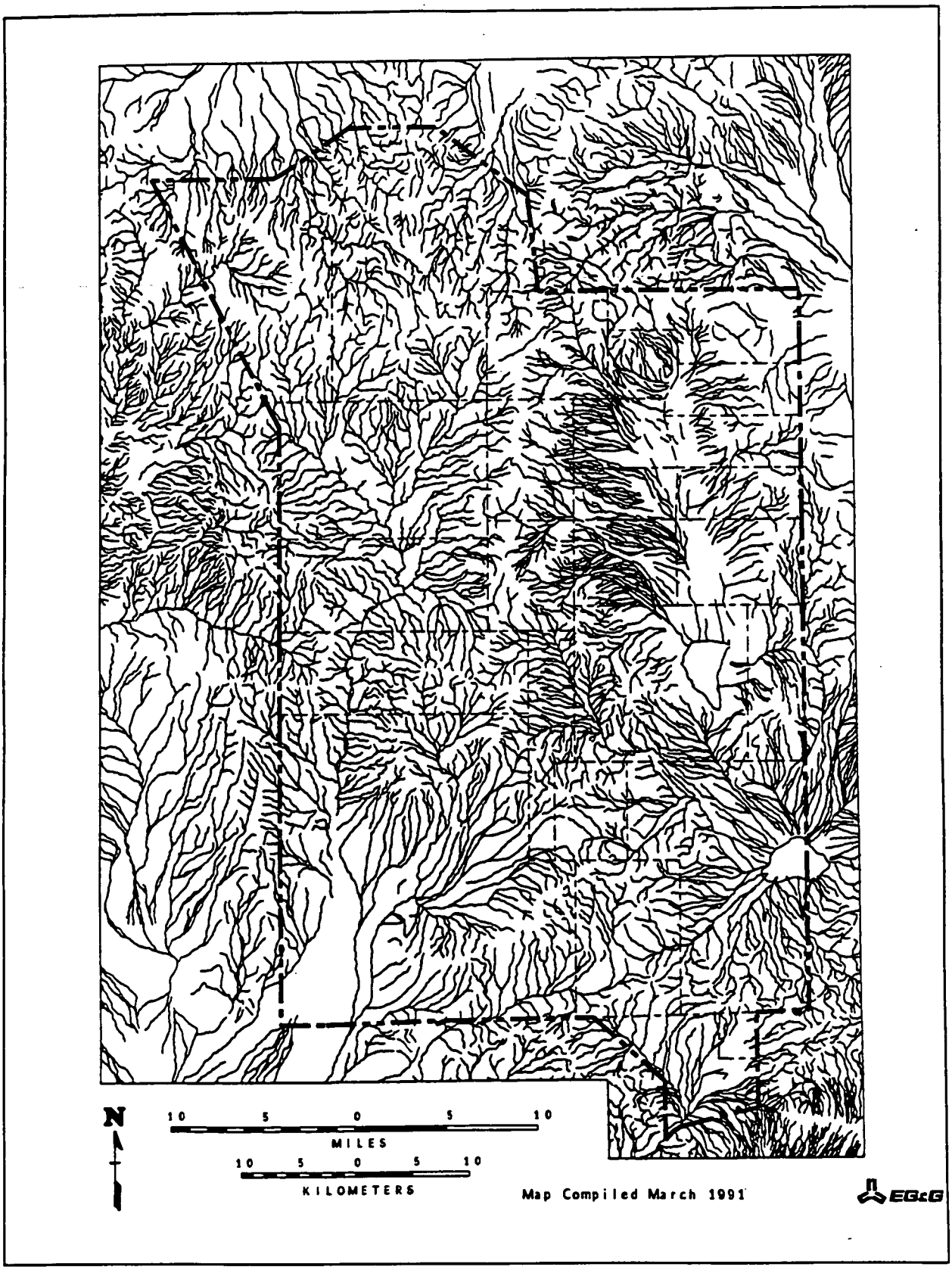

Figure 2.6 Surface Drainage Channel Pattern for the NTS

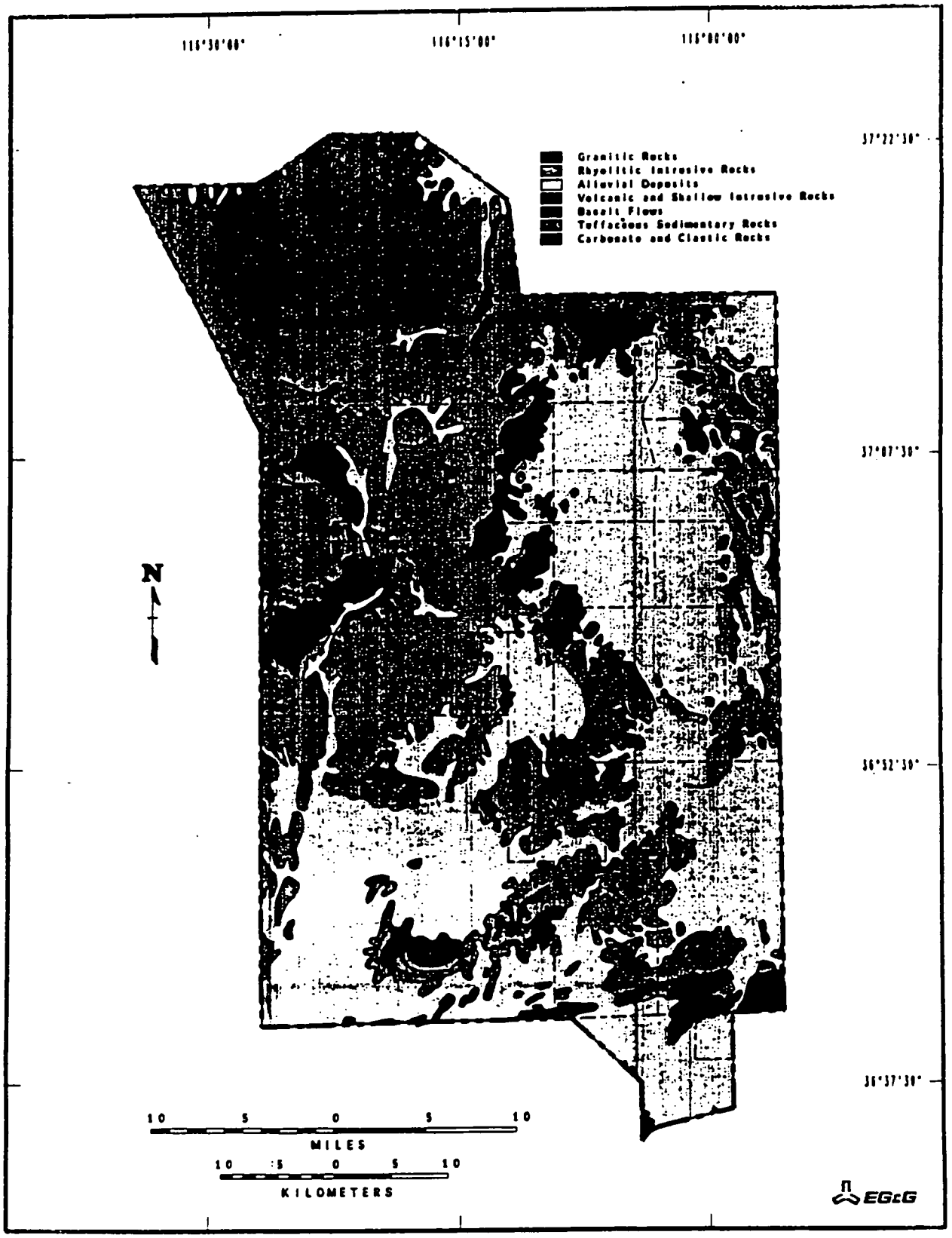

Figure 2.7 Basic Lithologic Structure of the NTS

the NTS is probably one of the better characterized large areas, geologically, within the U.S. The distribution of drill holes is shown in Figure 2.8.

In general the geology consists of three major rock units. These are (1) complexly folded and faulted sedimentary rocks of Paleozoic age overlain at many places by (2) volcanic tuffs and lavas of Tertiary age, which (in the valleys) are covered by (3) alluvium of late Tertiary and Quaternary age. The sedimentary rocks of Paleozoic age are many thousands of feet thick and are comprised mainly of carbonate rocks (dolomite and limestone) in the upper and lower parts, separated by a middle section of clastic rocks (shale and quartzite). The volcanic rocks in the valleys are down-dropped and tilted along steeply dipping normal faults of late Tertiary age. The alluvium is rarely faulted. Compared to the Paleozoic rocks, the Tertiary rocks are relatively undeformed, and dips are generally gentle. The alluvium is derived from erosion of the nearby hills of Tertiary and Paleozoic rocks.

The volcanic rocks of Tertiary age are predominantly tuffs, which erupted from various volcanic centers, and lavas, mostly of rhyolitic composition. The aggregate thickness of the volcanic rocks is many thousands of feet, but in most places the total thickness of the section is far less because of erosion or nondeposition. These materials erupted before the collapse of large volcanic centers known as *calderas*. Alluvial materials fill the intermountain valleys and cover the adjacent slopes. These sediments attain thicknesses of 600 to 900 m (2000 to 3000 ft) in the central portions of the valleys. The alluvium in Yucca Flat is vertically offset along the prominent north-south-trending Yucca fault.

2.1.6 HYDROGEOLOGY

Some nuclear tests are conducted below the groundwater table; the others are at varying depths above the groundwater table. Great depths to the groundwater table and the slow velocity of water movement in the saturated and unsaturated zones beneath the NTS are of particular significance in terms of low potential for radioactivity transport to offsite areas from nuclear tests or from shallow burial waste disposal sites. The deep aquifers, slow groundwater movement, and exceedingly slow downward movement of water in the overlying unsaturated zone serve as significant barriers to transport of radioactivity from underground sources via groundwater, greatly limiting the potential for transport of radioactivity to offsite areas.

Depths to groundwater beneath NTS vary from about 157 m (515 ft) beneath the Frenchman Flat playa (Winograd and Thordarson 1975) in the southern part of the NTS to more than 610 m (2000 ft) beneath part of Pahute Mesa. In the eastern portions of the NTS, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer. The flow in the shallower parts of the groundwater body is generally toward the major valleys (Yucca and Frenchman) where it deflects downward to join the regional drainage to the southwest in the carbonate aquifer.

The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley groundwater basin. The actual subbasin boundaries are poorly defined, as shown in Figure 2.9. Groundwater beneath the eastern part of the NTS is in the Ash Meadows subbasin, defined by discharge through evapotranspiration along a spring line in Ash Meadows (south of the NTS). Most of the western NTS is in the Alkali Flat/Furnace Creek Ranch subbasin, which discharges by evapotranspiration at Alkali Flat and by spring discharge near Furnace Creek Ranch. Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley subbasin, discharging by evapotranspiration in the Oasis Valley.

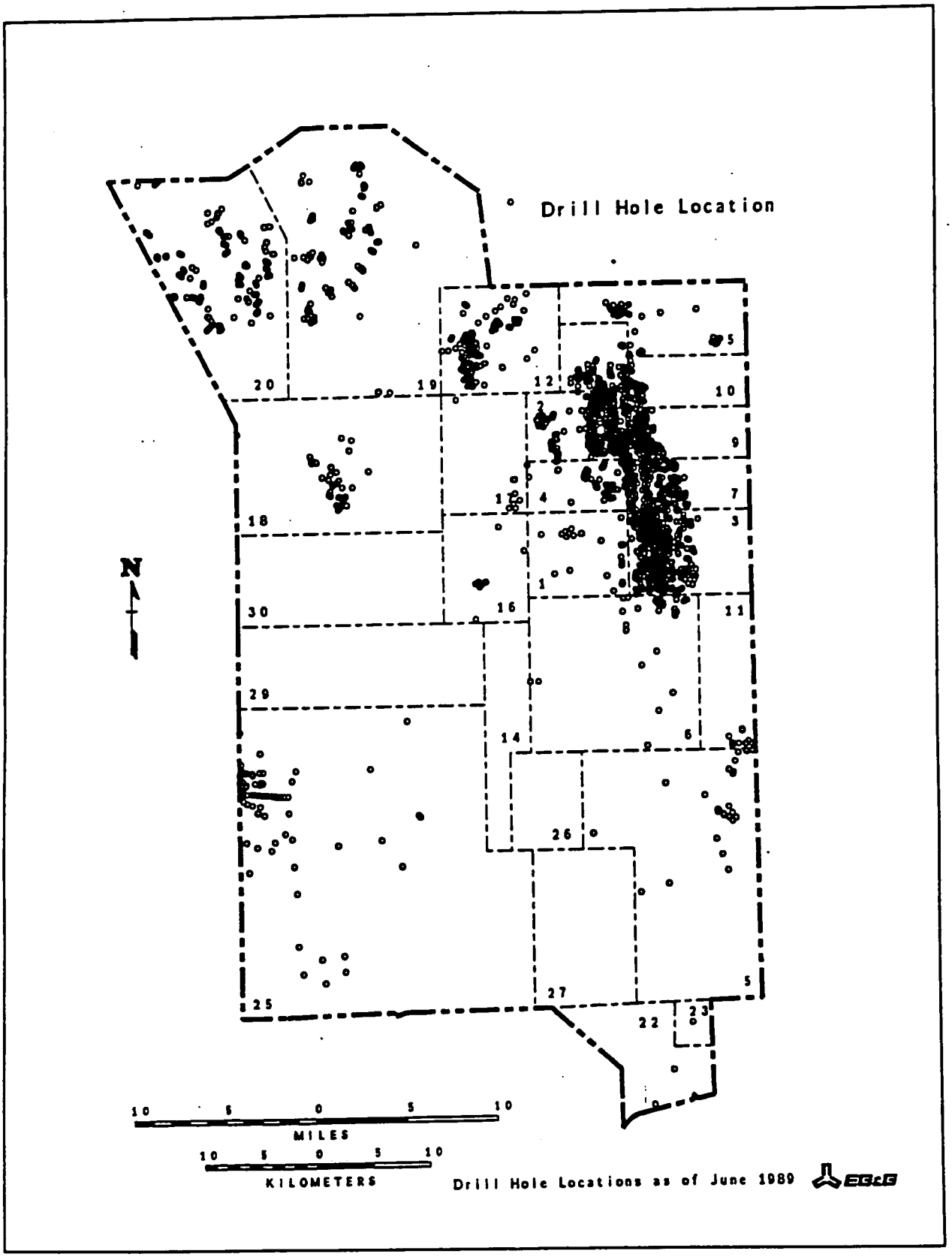

Figure 2.8 Drill Hole Locations on the NTS

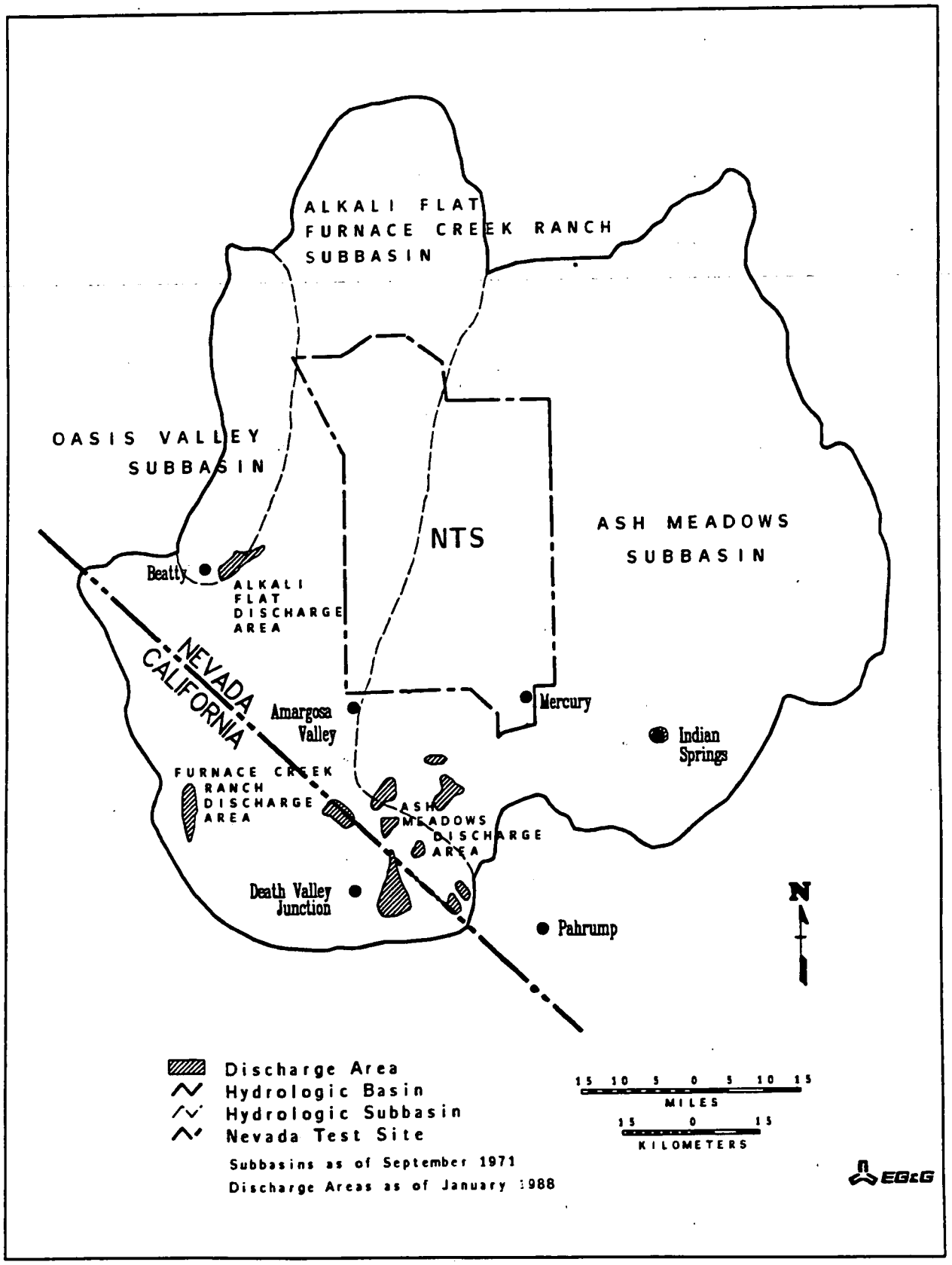

Figure 2.9 Groundwater Hydrologic Units of the NTS and Vicinity

Some underflow, past all of the subbasin discharge areas, probably travels to springs in Death Valley. Recharge for all of the subbasins most likely occurs by precipitation at higher elevations and infiltration along stream courses and in playas. Regional groundwater flow is from the upland recharge areas in the north and east towards discharge areas at Ash Meadows and Death Valley, southwest of the Site. Due to the large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions can be radically different from the regional trend. Groundwater is the only local source of drinking water in the NTS area. Drinking and industrial water supply wells for the NTS produce from the lower and upper carbonate, the volcanic and the valley-fill aquifers.Although a few springs emerge from perched groundwater lenses at the NTS, discharge rates are low, and spring water is not currently used for DOE activities. Wildlife use the springs for drinking water. South of the NTS, private and public supply wells are completed in a valley-fill aquifer.

The hydrogeology of the underground nuclear testing areas on the NTS (Figure 2.9) has been summarized by the Desert Research Institute, University of Nevada System, in its report on the groundwater monitoring program for the NTS (Russell 1990). Yucca Flat is situated within the Ash Meadows groundwater subbasin. Groundwater occurs within the valley fill, volcanic, and lower carbonate aquifers and in the volcanic, upper clastic, and lower clastic aquitards. The depth to water generally ranges from 160 meters (525 feet) to about 580 meters (1900 feet) below the ground surface. The tuff aquitard forms the principal Cenozoic hydrostratigraphic unit beneath the water table in the eastern two thirds of the valley and is unconfined over most of its extent. The welded tuff and bedded tuff aquifers are saturated beneath the central and northern parts of the valley and occur under both confined and unconfined conditions. The valley fill aquifer is saturated in the central part of the valley and is unconfined (Winograd and Thordarson 1975).

Frenchman Flat is also within the Ash Meadows subbasin. Regional groundwater flow in this valley occurs within the major Cenozoic and Paleozoic hydrostratigraphic units at depths ranging from 157 to 360 m (515 to 1180 ft) below the ground surface. Perched water is found as shallow as 20 m (66 ft) within the tuff and lava flow aquitards in the southwestern part of the valley. In general, the depth to water is least beneath Frenchman playa (157 m [515 ft]) and depths increase to nearly 360 m (1180 ft) near the margins of the valley (Winograd and Thordarson 1975). The water table beneath Frenchman Flat is considerably shallower (and stratigraphically higher) than beneath Yucca Flat. Consequently, the areal extent of saturation in the valley fill and volcanic aquifers is correspondingly greater.

Winograd and Thordarson (1975) hypothesized that groundwater within the Cenozoic units of Yucca and Frenchman Flats probably cannot leave these basins without passing through the underlying and surrounding lower carbonate aquifer. In addition, lateral gradients within the saturated volcanic units exist and may indicate groundwater flow toward the central areas of Yucca and Frenchman Flats prior to vertical drainage.

The only hydrostratigraphic units encountered at Pahute Mesa are the volcanic aquifers and aquitards. Pahute Mesa is thought to be a part of both the Oasis Valley and Alkali Flat/Furnace Creek Ranch subbasins. The location of the inter-basin boundary is uncertain. Groundwater is thought to move towards the south and southwest, through Oasis Valley, Crater Flat and western Jackass Flats (Blankennagel and Weir 1973). Points of discharge are thought to include the springs in Oasis Valley, Alkali Flat, and Furnace Creek. The amount of recharge to Pahute Mesa and the amount of underflow which moves to the various points of discharge are not accurately known. Vertical gradients within Pahute Mesa suggest that flow

may be downward in the eastern portion of the mesa but upward in the western part (Blankennagel and Weir 1973).

The hydrostratigraphic units beneath Rainier Mesa consist of the welded and bedded tuff aquifer, zeolitized tuff aquitard, the lower carbonate aquifer, and the tuffaceous and lower clastic aquitards. The volcanic aquifer and aquitards support a semiperched groundwater lens. Nuclear testing at Rainier Mesa is conducted within the tuff aquitard. Work by Thordarson (1965) indicates that the perched groundwater is moving downward into the underlying regional aquifer. Depending on the location of the subbasin boundary, Rainier Mesa groundwater may be part of either the Ash Meadows or the Alkali Flat/Furnace Creek Ranch subbasin. The regional flow from the mesa may be directed either towards Yucca Flat or, because of the intervening upper clastic aquitard, towards the Alkali Flat discharge area in the south. The nature of the regional flow system beneath Rainier Mesa has not been defined and requires further investigation.

2.1.7 CLIMATE AND METEOROLOGY

Precipitation levels on the NTS are low, runoff is intermittent, and the majority of the active testing areas on the NTS drain into closed basins on the Site. Annual precipitation in Southern Nevada is very light and depends largely upon elevation. A characteristic of desert climates is the temporal and spatial variability of precipitation. Topography contributes to this variability. For example, on the NTS the mesas receive an average annual precipitation of 23 cm (9 in.), which includes wintertime snow accumulations. The lower elevations receive approximately 15 cm (6 in.) of precipitation annually, with occasional snow accumulations lasting only a matter of days (Quiring 1968).

Precipitation usually falls in isolated showers with large variations in precipitation amounts within a shower area. Summer precipitation occurs mainly in July and August when intense heating of the ground below moist air masses (transported northward from the tropical Pacific Ocean through the Gulf of California and into the desert southwest) triggers thunderstorm development. On occasion a tropical storm will move northeastward from the west coast of Mexico, bringing widespread heavy precipitation to Southern Nevada during September and/or October.

Elevation also influences temperatures on the NTS. At an elevation of 2000 m (6560 ft) above MSL in Area 20 on Pahute Mesa, the average daily maximum/minimum temperatures are 4.4°/-2.2°C (40°/28°F) in January and 26.7°/16.7°C (80°/62°F) in July. In Area 6 (Yucca Flat, 1200 m (3920 ft MSL), the average daily maximum/minimum temperatures are 10.6°/-6.1°C (51°/21°F) in January and 35.6°/13.9°C (96°/57°^F) in July.

Wind direction and speed are important aspects of the environment at the NTS. These are major factors in planning and conducting nuclear tests, where atmospheric transport is the primary potential route of contamination transport to onsite workers and offsite populations.

The movements of large-scale pressure systems control the seasonal changes in the wind direction frequencies. Predominating winds are southerly during summer and northerly during winter. The general downward slope in the terrain from north to south results in an intermediate scenario that is reflected in the characteristic diurnal wind reversal from southerly winds during the day to northerly winds at night. This north to south reversal is strongest in the summer and, on occasion, becomes intense enough to override the wind regime associated with large-scale pressure systems. This scenario is very sensitive to the orientation of the mountain slopes and valleys.

At higher elevations in Area 20, the average annual wind speed is 17 kilometers per hour (km/h: 10 miles per hr [mph]). The prevailing wind direction during winter months is from north-northeast, and, during summer months, winds prevail from the south. In Yucca Flat the average annual wind speed is 11 km/h (7 mph). The prevailing wind direction during winter months is north-northwest and during summer months is south-southwest. At Mercury the average annual wind speed is 13 km/h (8 mph),with a prevailing wind direction of northwest during the winter months and southwest during the summer months. The 1991 ten-meter wind roses for the NTS are shown in Figure 2.10.

2.1.8 FLORA AND FAUNA

The greater part of the NTS is vegetated by various associations of desert shrubs typical of the Mojave or Great Basin Deserts or the zone of transition desert between these two. There are areas of desert woodland (piñon, juniper) at higher elevations. Even there, typical Great Basin shrubs, principally sagebrushes, are a conspicuous component of the vegetation. Although shrubs (or shrubs and small trees) are the dominant forms, herbaceous plants are well represented in the flora and play an important role in supporting animal life.

Extensive floral collection has yielded 711 taxa of vascular plants within or near the boundaries of the NTS (O'Farrell and Emery 1976). Associations of creosote bush, *Larrea tridentata*, which are characteristic of the Mojave Desert, dominate the vegetation mosaic on the bajadas of the southern NTS. Between 1220 and 1520 m (4000 and 5000 ft) in elevation in Yucca Flat, transitional associations are dominated by *Grayia spinosa-Lycium andersonii* (hopsage/desert thorn) associations, while the upper bajadas support *Coleogyne* types. Above 1520 m (5000 ft) the vegetation mosaic is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* ssp. *nova*. Above 1830 meters (6000 feet) piñon pine and juniper mix with the sagebrush associations where there is suitable moisture for these trees. No plant species located on the NTS is currently on the federal endangered species list; however, the state of Nevada has placed *Astragalus beatleyae* on its critically endangered species list.

Most mammals on the NTS are small and secretive (often nocturnal in habitat), hence not often seen by casual observers; larger mammals include feral horses, burros, deer, mountain lions, bobcats, coyote, kit foxes, and rabbits. Reptiles include four species of venomous snakes; bird species are mostly migrants or seasonal residents. Rodents are, in terms of distribution and relative abundance, the most important group of mammals on the NTS. Most nonrodent mammals have been placed in the "protected" classification by the state of Nevada.

In 1989 the desert tortoise, *Gopherus agassizii*, was placed on the endangered species list by the U.S. Department of Interior and was relisted as threatened in 1991. Tortoise habitats on the NTS are found in the southern third of the NTS outside the current areas of nuclear test activities in Yucca Flat, Rainier Mesa, and Pahute Mesa.

2.1.9 ARCHAEOLOGICAL AND HISTORICAL VALUES

Human habitation of the NTS area ranges from as early as 10,000 B.C. to the present. Various aboriginal cultures occupied the NTS area over this extended period as evidenced by the presence of artifacts at many surface sites and more substantial deposits of cultural material in several rock shelters. This period of aboriginal occupation was sustained primarily by a hunting and gathering economy based on using temporary campsites and shelters. The area was occupied by Paiute Indians at the time of the first known outside contact in 1849.

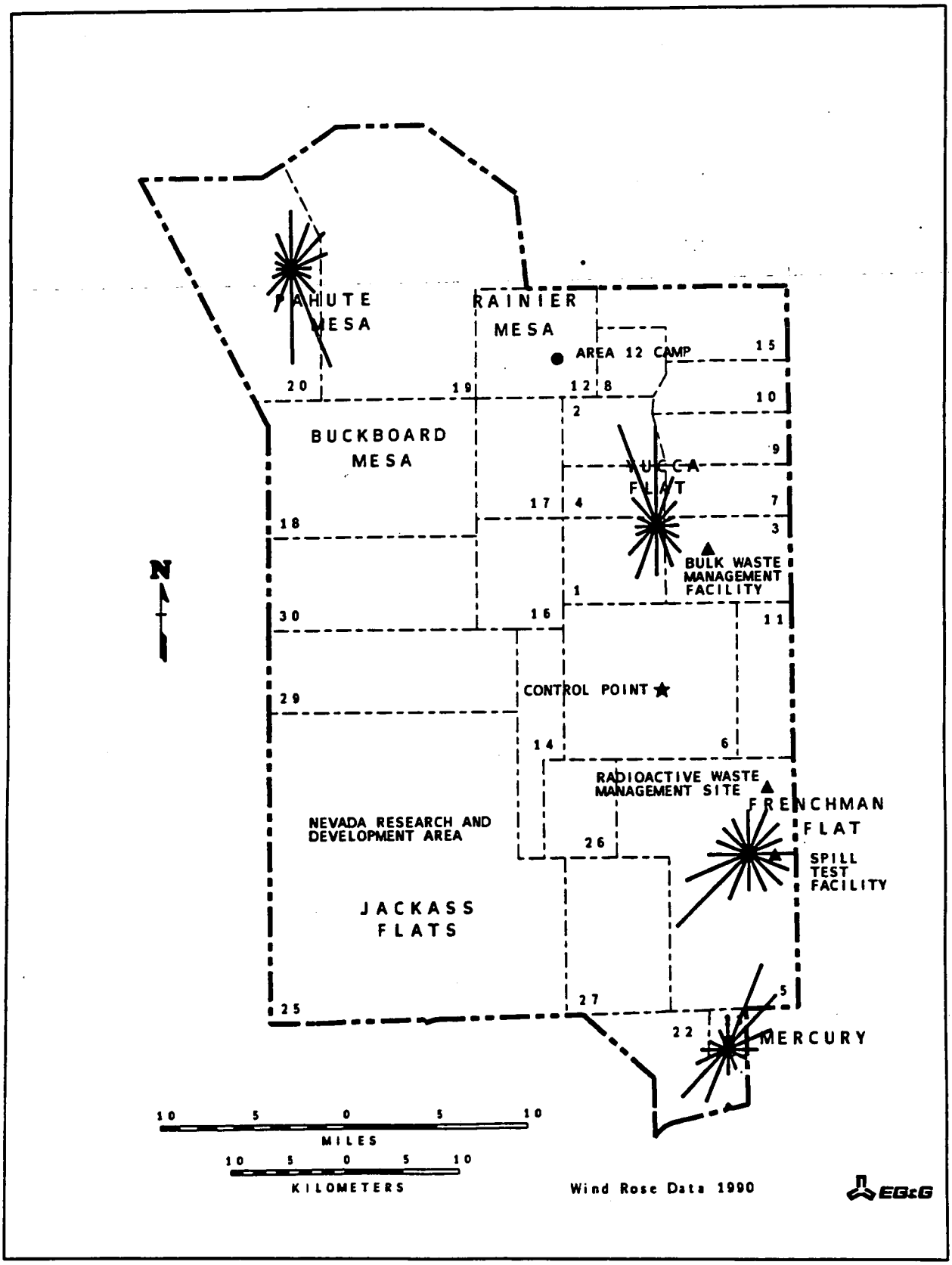

Figure 2.10 1991 Wind Rose Patterns for the NTS (Courtesy of Weather Services Nuclear Support Office, NOAA)

Because readily available surface water was the most important single determinant governing the location of human occupation, historic sites are often associated with prehistoric ones, both being situated near springs. As a consequence of this superposition of historic occupation, disturbance of certain aboriginal sites by modern man occurred long before use of the area as a nuclear testing facility began. The larger valleys show little or no evidence of occupation. Together these areas comprise almost the entire floors of Yucca, Frenchman, and Jackass Flats. Thus, testing and associated operational activities have generally been most intense in those parts of the NTS where archaeological and historic sites are absent.

In addition to the archaeological sites, there are also some sites of historical interest on the NTS. The principal sites include the remains of primitive stone cabins with nearby corrals at three springs, a natural cave containing prospector's paraphernalia in Area 30, and crude remains of early mining and smelting activities. Even sites on the periphery of Yucca Flat, close to the area of repeated underground testing, seem to have been little affected by ground motion from tests. The stone cabin at Tippipah Spring, less than ten miles from numerous tests, was found to be essentially unchanged in spite of testing over an eight-year period (Norman 1969).

2.1.10 DEMOGRAPHY

Figure 2.11 shows the current population of counties surrounding the NTS, based on 1991 Bureau of Census estimates (DOC 1990). Excluding Clark County, the major population center (approximately 741,000 in 1990), the population density within a 150-kilometer radius of the NTS is about 0.5 persons per square kilometer. In comparison, the 48 contiguous states (1990 census) had a population density of approximately 29 persons per square kilometer. The estimated average population density for Nevada in 1990 was 2.8 persons per square kilometer.

The offsite area within 80 kilometers of the NTS Control Point is predominantly rural. CP-1 (a building at the Control Point) historically has been the point from which distances from the NTS were determined. Several small communities are located in the area, the largest being in the Pahrump Valley. This growing rural community, with an estimated population of 15,000, is located 80 kilometers south of CP-1. The Amargosa Farm area, which has a population of about 950, is located about 50 kilometers southwest of CP-1. The largest town in the near offsite area is Beatty, which has a population of about 1500 and is located approximately 65 kilometers to the west of CP-1.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service (NPS 1990) estimated that the population within the Monument boundaries ranges from a minimum of 200 permanent residents during the summer months to as many as 5000 tourists and campers on any particular day during the major holiday periods in the winter months. As many as 30,000 are in the area during "Death Valley Days" in the month of November. The next largest town and contiguously populated area (about 40 square miles) in the Mojave Desert is Barstow, California, located 265 kilometers south-southwest of the NTS, with a 1991 population of about 21,000. The largest populated area is the Ridgecrest-China Lake area, which has a current population of 28,000 and is located 190 kilometers southwest of the NTS. The Owens Valley, where numerous small towns are located, lies 50 kilometers west of Death Valley. The largest town in the Owens Valley is Bishop, located 225 kilometers west-northwest of the NTS, with a population of 3500.

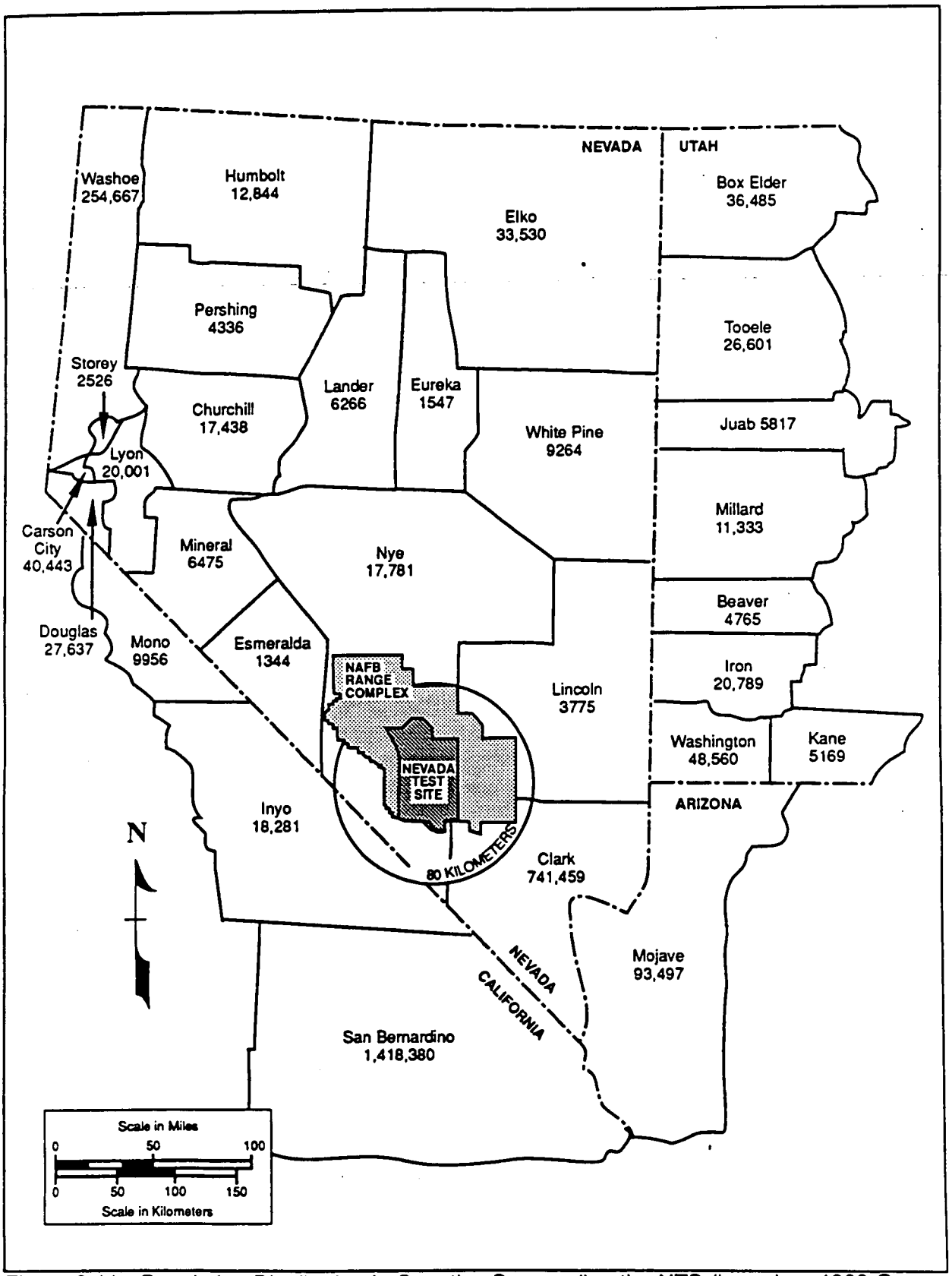

Figure 2.11 Population Distribution in Counties Surrounding the NTS (based on 1990 Census estimates)

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The largest community is St. George, located 220 kilometers east of the NTS, with a 1991 population of 29,000. The next largest town, Cedar City, with a population of 13,000, is located 280 kilometers east-northeast of the NTS.

The extreme northwestern region of Arizona is mostly range land except for that portion in the Lake Mead Recreation Area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 kilometers south-southeast of the NTS, with a 1991 population estimate of 22,000, and Kingman, located 280 kilometers southeast of the NTS, with a population of about 13,000.

2.1.11 SURROUNDING LAND USE

Figure 2.12 is a map of the offsite area showing a wide variety of land uses such as farming, mining, grazing, camping, fishing, and hunting within a 300-km (180-mile) radius of the CP-1. West of the NTS elevations range from 85 m (280 ft) below MSL in Death Valley to 4400 m (14,500 ft) above MSL in the Sierra Nevada Range, including parts of two major agricultural valleys (the Owens and San Joaquin). The areas south of the NTS are more uniform since the Mojave Desert ecosystem (mid-latitude desert) comprises most of this portion of Nevada, California, and Arizona. The areas east of the NTS are primarily mid-latitude steppe with some of the older river valleys, such as the Virgin River Valley and Moapa Valley, supporting irrigation for small-scale but intensive farming of a variety of crops.. Grazing is also common in this area, particularly towards the northeast. The area north of the NTS is also mid-latitude steppe where the major agricultural activity is grazing of cattle and sheep. Minor agriculture, primarily the growing of alfalfa hay, is found in this portion of the state within 300 km (180 mi.) of CP-1. Many of the residents have access to locally grown fruits and vegetables.

Recreational areas lie in all directions around the NTS and are used for such activities as hunting, fishing, and camping. In general the camping and fishing sites to the northwest, north, and northeast of the NTS are utilized throughout the year except for the winter months. Camping and fishing locations to the southeast, south, and southwest are utilized throughout the entire year. The peak hunting season is from September through January.

2.2 NON-NTS FACILITIES

EG&G/EM has several offsite operations in support of activities at the NTS under a contract with the DOE/NV. These operations house the Amador Valley Operations (AVO), Pleasanton, California; Kirtland Operations (KO), Kirtland Air Force Base (KAFB), Albuquerque, New Mexico; Las Vegas Area Operations (LVAO) that include the Remote Sensing Laboratory at the NAFB and North Las Vegas Complex in North Las Vegas, Nevada; Los Alamos Operations (LAO), Los Alamos, New Mexico; Santa Barbara Operations (SBO) that includes the Robin Hill Road and Francis Botello Road Facilities, Goleta, California; Special Technologies Laboratory (STL), Santa Barbara, California; Washington Aerial Measurements Department (WAMD), Andrews Air Force Base, Maryland; and Woburn Cathode Ray Tube Operations (WCO), Woburn, Massachusetts. These locations are shown in Figure 2.13. Each of these facilities is located in a metropolitan area. City, county, and state regulations govern emissions, waste disposal, and sewage. No independent systems exist for supplying drinking water or sewage disposal, and hazardous waste is moved off the facility sites for disposal. Radiation sources are sealed, and no radiological emissions are possible during normal facility operations.

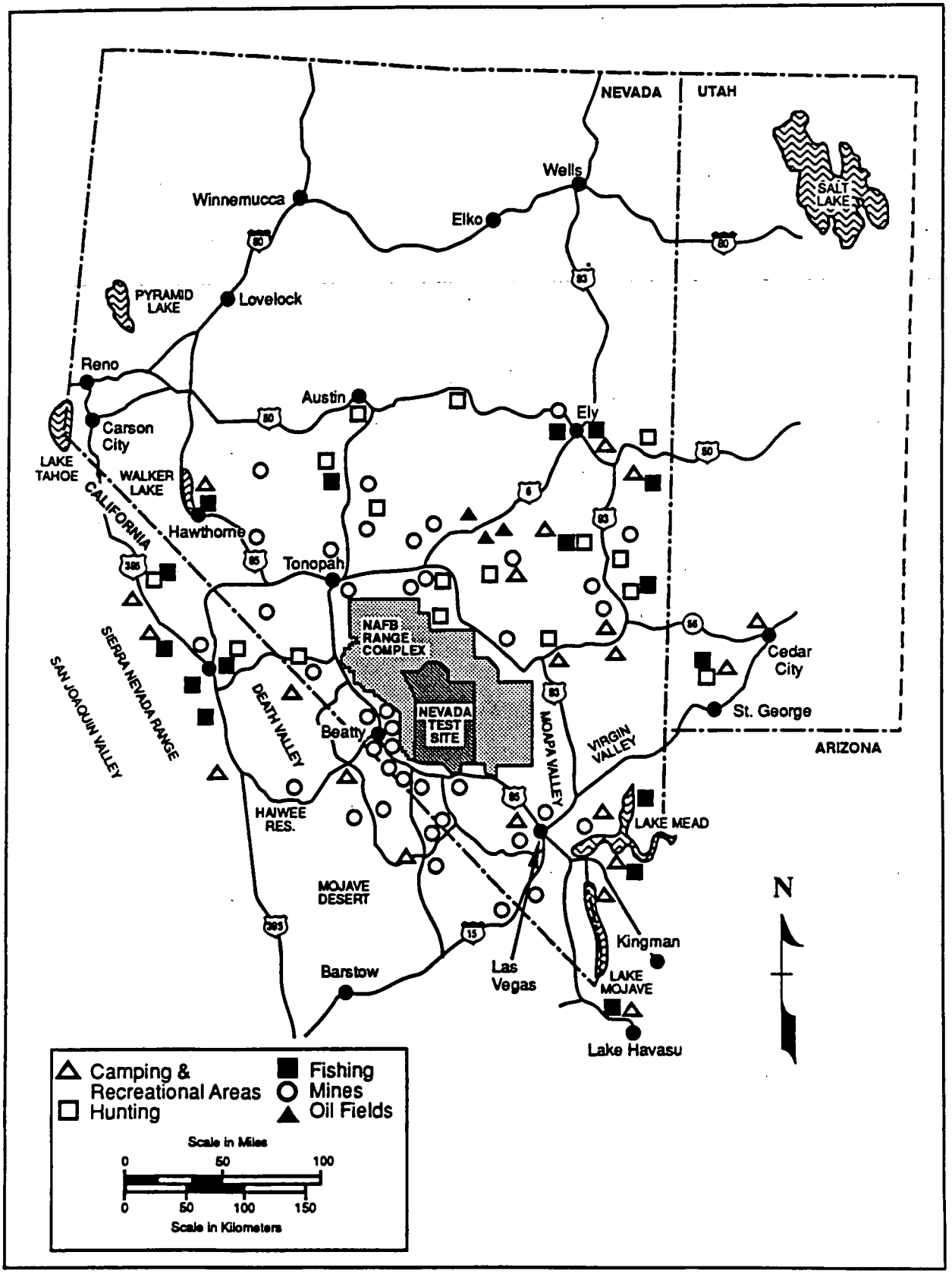

Figure 2.12 Land Use Around the NTS

2.2.1 AMADOR VALLEY OPERATIONS

The AVO facility in Pleasanton, California, occupies a 100,000 square-foot (9290 square-meter) facility consisting of two large combination office/laboratory buildings, one two-story and one single-story. The facility is located near the Lawrence Livermore National Laboratory (LLNL) in Livermore, California, to simplify logistics and communications associated with EG&G/EM support of LLNL programs. Most of the work is in support of NTS underground weapons testing. AVO also supports LLNL with optical alignment systems, fast-streak camera fabrication, and a variety of mechanical and electrical engineering activities associated with energy research and development programs. Fields of specialized experience represented at AVO include the design and fabrication of cathode-ray tubes for use in the weapons testprogram. Areas of environmental interest include several localized exhaust hoods and small chemical cleaning operations.

2.2.2 KIRTLAND OPERATIONS

KO at KAFB and in Albuquerque, New Mexico, consists of a 5200 square-meter (56,000 square-foot) complex of prefabricated metal buildings located on 1.60 hectares (39.5 acres) at KAFB, and a 3250 square-meter (35,000 square-foot) industrial facility, called the Craddock Facility, located near the Albuquerque International Airport. KO provides technical support to SNL, the DOE, the Department of Defense (DOD), and other federal agencies. In conjunction with DOE work, KO provides significant support to a variety of ongoing safeguards and security programs. KO is also responsible for operation of the System Control and Receiving Station (SCARS), a part of the DOE Remote Seismic Test Network (RSTN). Areas of environmental interest include small solvent cleaning and painting operations and a small metal finishing shop.

2.2.3 LAS VEGAS AREA OPERATIONS

The LVAO includes the North Las Vegas facility at 2621 Losee Road and the Remote Sensing Laboratory on the NAFB in North Las Vegas, Nevada. These facilities provide technical support for the DOE/NV test program.

The North Las Vegas facility includes multiple structures totaling about 37,200 square meters (400,000 square feet). At the facility there are numerous areas of environmental interest, including metal finishing operations, a radiation source range, an X-ray laboratory, solvent and chemical cleaning operations, small amounts of pesticide and herbicide application, photo laboratories, and hazardous waste generation and accumulation.

The Remote Sensing Laboratory is a 11,000 square-meter (118,000 square-foot) facility located on a 140 hectares (35-acre) site within the confines of the NAFB. The facility includes space for aircraft maintenance and operations, mechanical and electronics assembly, computer operations, photo processing, a light laboratory, and warehousing. Areas of environmental interest are photo processing and aircraft maintenance and operations.

2.2.4 LOS ALAMOS OPERATIONS

The LAO resides in a facility of approximately 6040 square meters (65,000 square feet). It is a two-story combination engineering/laboratory/office complex located near the LANL facility to provide local support for LANL's programs. The work performed includes direct support of the LANL testing program, the DOE Research and Development (R&D) Program, and

miscellaneous DOE cash-order work. LAO's primary activities are twofold: (1) the design, fabrication, and fielding of data acquisition systems used in underground nuclear testing diagnostics and (2) the analysis of data from underground and high-altitude experiments. In addition, two LAO operations build and field CORRTEX III recorders. Areas of environmental interest include small solvent cleaning, metal machining operations, and a small photo laboratory.

2.2.5 SANTA BARBARA OPERATIONS

The SBO facility consists of a combination office/laboratory building of approximately 5760 m^2 (62,000 ft^2), including a specialized radiation research building that houses the DOE-EG&G/EM linear accelerator (LINAC) and accompanying laboratories. Several small machine shops, laboratory buildings, and a source range are located on county property. In support of the DOE/NV, the SBO was established for R&D work in nuclear instrumentation and measurements with emphasis on radiation detectors, data acquisition systems, and fast pulse electronics. Through the years its facilities have been adapted to a wide range of R&D tasks. The SBO also describes and assesses the potential ecological impacts of various DOE projects on ecological systems of interest. Activities of environmental interest include a mercuric iodide laboratory (where mercuric iodide crystals are grown), minor solvent operations, and several fume hoods.

2.2.6 SPECIAL TECHNOLOGIES LABORATORY

The STL located in Santa Barbara, California, consists of approximately 3340 square meters (36,000 square feet) of secure combination office/laboratory area used primarily for engineering and electronic research. The research is conducted to develop a suite of sensor systems for testing and field deployment in support of DOE Headquarters and DOE/NV. Areas of environmental interest include a small printed circuit board operation and limited solvent cleaning operations. STL also supports LLNL with optical alignment systems, fast-streak camera fabrication, and a variety of mechanical and electrical engineering activities associated with energy R&D programs. Fields of specialized experience represented at STL include the design and fabrication of cathode-ray tubes for use in the weapons test program. Areas of environmental interest include several localized exhaust hoods and small chemical cleaning operations.

2.2.7 WASHINGTON AERIAL MEASUREMENTS DEPARTMENT

The WAMD, located at Andrews Air Force Base, consists of a 186 square-meter (2000 square-foot) Butler building used as office space; a 1110 square-meter (12,000 square-foot) combination electronics laboratory, aircraft maintenance, and office complex; and a portion of a large aircraft hangar. WAMD operations provides an effective East Coast Nuclear Emergency Search Team (NEST) response capability and provides an eastern aerial survey capacity to the DOE/NV. Areas of environmental interest include small solvent cleaning operations and used fuels and oils.

2.2.8 WOBURN CATHODE RAY TUBE OPERATIONS

The WCO in Woburn, Massachusetts, is comprised of a 1300 square-meter (14,000 square-foot) facility which is used to develop and manufacture advanced cathode-ray tubes and oscilloscopes in support of the DOE/NV LANL Test Program for use in the weapons test

program. Areas of environmental interest include small solvent cleaning operations and several laboratory hoods, and a dry well for discharging uncontaminated, non-contact cooling water.

2.3 NON-NTS UNDERGROUND EVENT SITES

Non-NTS tests were conducted in eight locations in the continental U.S. These events and their locations appear in Figure 2.13 and Table 2.2. Activities at these locations are limited to sampling at 217 wells, springs, and other sources at locations near sites where nuclear explosive tests were conducted. Sampling results for these sjtes appear in Section 9 of this volume. (Sampling at the Amchitka Island sites occurs biannually; no sampling was performed in 1991.)

Table 2.2 Non-NTS Nuclear Explosive Test Sites Studied in 1991

Event Name	Location	Date of Test
GNOME	Malaga, New Mexico	12/10/61
SHOAL	Fallon, Nevada	10/26/63
SALMON (Dribble)	Baxterville, Mississippi	10/22/64
LONG SHOT	Amchitka Island, Alaska	10/29/65
STERLING (Dribble)	Baxterville, Mississippi	12/03/66
GASBUGGY	Gobernador, New Mexico	12/10/67
FAULTLESS	Blue Jay, Nevada	01/19/68
RULISON	Grand Valley, Colorado	09/10/69
MILROW	Amchitka Island, Alaska	10/02/69
CANNIKIN	Amchitka Island, Alaska	11/06/71
RIO BLANCO	Rio Blanco, Colorado	05/17/73

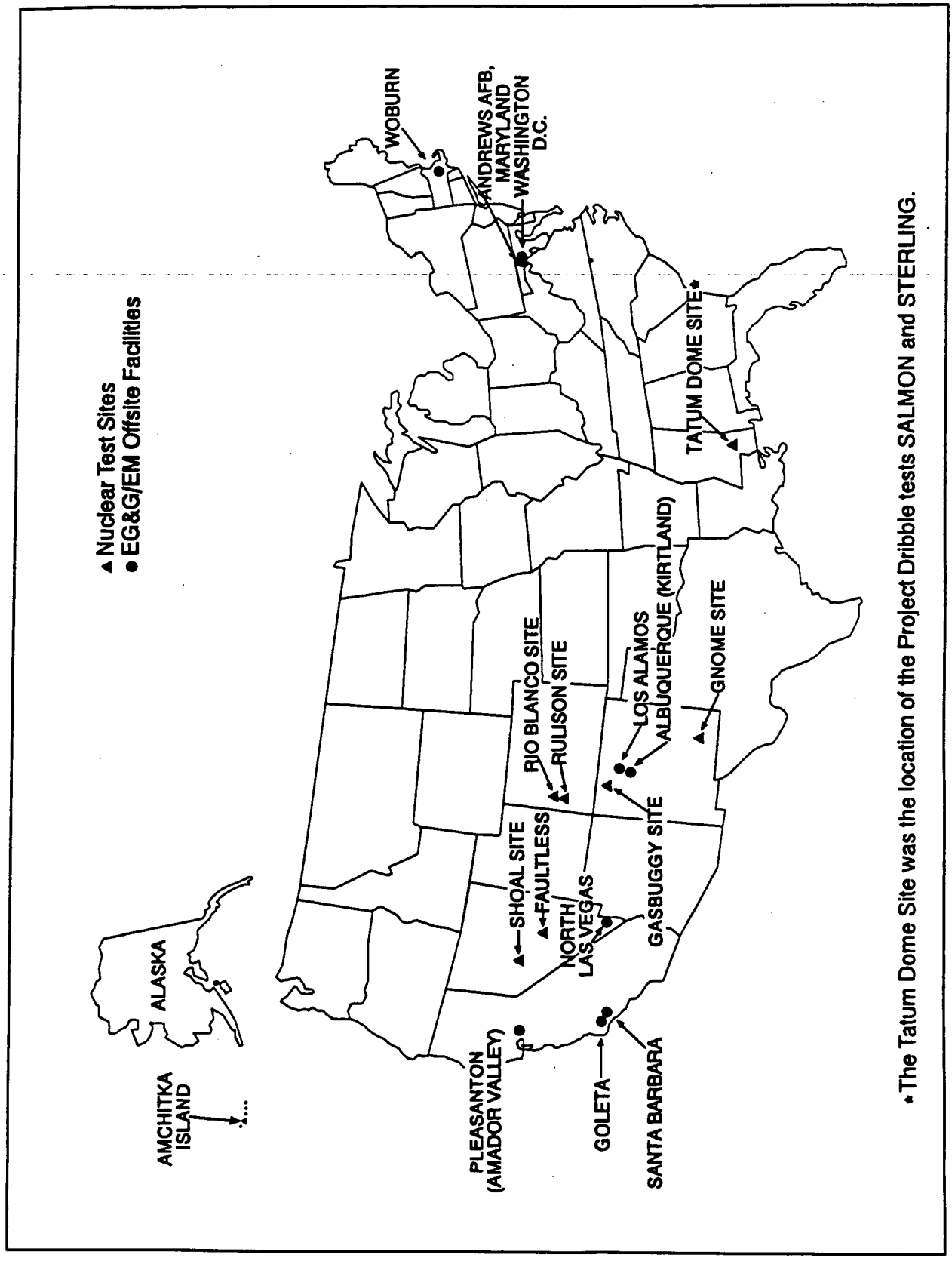

Figure 2.13 Locations of Non-NTS Operations and Underground Event Sites

3.0 COMPLIANCE SUMMARY

H. Bruce Gillen, Scott E. Patton, Carlton S. Soong

In addition to conducting the nuclear testing programs in compliance with radiation protection guides and standards, the predominant environmental compliance activities at the NTS during the period from January 1991 through March 1992 involved hazardous waste management associated with Resource Conservation and Recovery Act (RCRA) requirements. Clean Air Act compliance involved sampling and reporting of asbestos renovation projects and state of Nevada air quality permit renewals and reporting. Toxic Substances Control Act (TSCA) compliance activities were concerned with polychlorinated biphenyl (PCB) management practices on the NTS. Compliance actions also included pre-operational surveys to protect and preserve archaeological and cultural history sites on the NTS. Compliance with the Endangered Species Act involved conducting pre-operations surveys to ensure continued existence of state of Nevada and federally listed endangered or threatened plant and animal species. There were no activities requiring compliance with Executive Orders 11988, Flood Plain Management, or 11990, Protection of Wetlands.

Findings communicated by the DOE "Tiger Team" during its October 1989 assessment of environmental compliance and program management continued to prompt corrective actions.

Throughout 1991 the NTS was subject to three formal compliance agreements with federal or state regulatory agencies: the American Indian Religious Freedom Act Compliance Program, a Programmatic Agreement with the Nevada Division of Historic Preservation and Archaeology and the Advisory Council on Historic Preservation, and the *Astragalus beatleyae* Conservation Agreement. No lawsuits have been identified that affect the DOE/NV's program obligations. Waste minimization efforts at the NTS were expanded in 1991.

Operations at the DOE/NV non-NTS facilities operated by EG&G/Energy Measurements, Inc. (EG&G/EM), involved compliance with the permitting and monitoring requirements of (1) the Clean Air Act for airborne emissions, (2) the Clean Water Act for wastewater, (3) state Safe Drinking Water Act (SDWA) regulations, (4) RCRA disposal of hazardous wastes, and (5) hazardous substance reporting. Waste minimization efforts extended to all EG&G/EM operations.

3.1 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA related activities included 14 Environmental Assessments and 55 Categorical Exclusions. Table 3.1 lists these activities in chronological order with the assigned number and their present status.

Table 3.1 NEPA Documentation - 1989-1991

Document No.	Description	Category	Review Status
NV-89-06	Depleted Uranium Tests, Ballistic Research Laboratory, Area 25	Environmental Assmt.	State Review
NV-89-07	Mixed Waste Management Unit, Area 5	Environmental Assmt.	At HQ EH
NV-89-21	Device Assembly Facility, Area 6	Environmental Assmt.	At EEM/NV
NV-89-30	SCYLLA Facility in Area 26	Environmental Assmt.	Pending Budget
NV-90-13	NTS Groundwater Characterization Program	Environmental Assmt.	At DOE/HQ/EM
NV-90-20	Road 5-01 Upgrade in Area 5	Categorical Exclus.	At DOE/NV
NV-90-51	Liquified Gaseous Fuels Spill Test Facility, Area 5	Environmental Assmt.	At DOE/NV
NV-90-58	Modifications to Building 102, Area 1	Categorical Exclus.	Approved 6/8/90
NV-90-63	New Decontamination Pond, Area 6	Environmental Assmt.	At NTSO
NV-90-96	Rainier Mesa Power Loop, Area 12	Environmental Assmt.	At NTSO
NV-90-101	Building 650 Closure Plan, Area 23	Categorical Exclus.	Approved 7/17/91
NV-90-102	Closure Plan for old Decontamination Pond, Area 6	Categorical Exclus.	Approved 7/17/91
NV-90-107	NTS Power Distribution	Environmental Assmt.	At EEM, DOE/NV
NV-90-136	Temporary Monitor Trailer, Able Compound, Area 27	Categorical Exclus.	Pending
NV-90-137	Fleet Operations Steam Cleaning Pad, Area 12	Categorical Exclus.	Pending
NV-90-139	U.S./U.S.S.R. Onsite Inspection Team Housing, Nevada Test Site	Environmental Assmt.	At EPD/NV
NV-90-140	Truck Parking Area, Radioactive Waste Management Site, Area 5	Categorical Exclus.	Approved 10/16/91
NV-90-141	Special Projects Building, Radioactive Waste Management Site, Area 5	Categorical Exclus.	Approved 11/25/91
NV-90-142	Equipment Maintenance Building, Radioactive Waste Management Site, Area 5	Categorical Exclus.	Approved 11/25/91
NV-90-143	Hazardous Waste Support Building, Radioactive Waste Management Site, Area 5	Categorical Exclus.	Approved 11/25/91

Table 3.1 (NEPA Documentation - 1989-1991, cont.)

Document No.	Description	Category	Review Status
NV-90-144	Integrated Demonstration Project (remove Pu from soil), Area 25	Categorical Exclus.	At HQ, EM
NV-91-001	Land Surface Cleanup Research & Development	Environmental Assmt.	At HQ, EM
NV-91-002	Building 1103 Addition, Area 23	Categorical Exclus.	Approved 1/29/91
NV-91-003	Physical Fitness Facility, Area 23	Categorical Exclus.	Approved 1/29/91
NV-91-004	Air Response Team Hangar Fence and Access Road, Area 6	Categorical Exclus.	Approved 1/24/91
NV-91-005	Radioactive Waste Management Site Study Trenches, Area 5	Categorical Exclus.	Approved 6/20/91
NV-91-006	Underground Storage Tank Modifications, NTS	Categorical Exclus.	Approved 12/30/91
NV-91-007	Steam Cleaning Pad and Lagoon, Area 6	Categorical Exclus.	Approved 1/29/91
NV-91-008	Building 1014 Emergency Exit, Area 23	Categorical Exclus.	Cancelled
NV-91-009	Munitions Magazine, Area 23	Categorical Exclus.	Cancelled
NV-91-010	Well Houses 5B and C1, Areas 5 and 6	Categorical Exclus.	Cancelled
NV-91-011	Real-Time Radiography Building, Area 5	Categorical Exclus.	Closed
NV-91-012	Technology Development Well, Area 12	Categorical Exclus.	Approved 2/6/91
NV-91-013	Open File		
NV-91-014	U.S. Army Depleted Uranium Testing, Area 25	--	Withdrawn
NV-91-015	Penetrator Test	--	Withdrawn
NV-91-016	Nevada Bell Optic Cable, Areas 5, 6, 22, and 23	Environmental Assmt.	At DOE/AD
NV-91-017	Material Recycling Unit, Area 3	Categorical Exclus.	Approved 10/15/91
NV-91-018	Building 160 Loading Dock Repair, Area 23	Categorical Exclus.	Approved 4/1/91
NV-91-019	Closed-Loop Steam Cleaning System, Area 1	Categorical Exclus.	Approved 4/4/91
NV-91-020	Telephone Cable Upgrade, Area 6	Categorical Exclus.	Approved 4/5/91

Table 3.1 (NEPA Documentation - 1989-1991, cont.)

Document No.	Description	Category	Review Status
NV-91-021	Onsite Inspection Agency Storage Building, Area 23	Categorical Exclus.	Approved 4/1/91
NV-91-022	Sewage Lagoon Monitoring, NTS	Categorical Exclus.	Pending
NV-91-023	N Tunnel Discharge Pipe Modifications, Area 12	Categorical Exclus.	Approved 4/18/91
NV-91-024	Compressed Gas Bottle Station, Building 650, Area 23	Categorical Exclus.	Approved 4/18/91
NV-91-025	T Tunnel Discharge Pipe Modifications, Area 12	Categorical Exclus.	Approved 5/8/91
NV-91-026	Overhead Power Line and Access Road, 4.16 kV, Area 5	Categorical Exclus.	Approved 5/14/91
NV-91-027	Fire Sprinkler System for Buildings 110 and 112, Area 23	Categorical Exclus.	Approved 5/2/91
NV-9--028	Uninterruptible Power Source Installation for Building 650, Area 23	Categorical Exclus.	Approved 5/2/91
NV-91-029	Jumper Fabrication Building Modifications, DNA, Area 12	Categorical Exclus.	Approved 5/10/91
NV-91-030	Site Characterization Wells for RCRA Permit Application, Area 5	Categorical Exclus.	Approved 10/16/91
NV-91-031	Brilliant Pebbles Bren Tower Tether Test, Area 25	Environmental Assmt.	At HQ/DP
NV-91-032	Powerline Reconducting	Categorical Exclus.	Approved 6/17/91
NV-91-033	Public Address System, Area 23	Categorical Exclus.	Approved 6/25/91
NV-91-034	Warehouse 8 Addition, Area 23	Categorical Exclus.	Approved 6/17/91
NV-91-035	Install Cardboard Balers, Areas 12 and 23	Categorical Exclus.	Approved 7/12/91
NV-91-036	Upgrade NTS Firing Range, Area 23	Categorical Exclus.	Approved 8/2/91
NV-91-037	Install Waste Compactors, Areas 6, 12, and 23	Categorical Exclus.	Approved 8/2/91
NV-91-038	Storm Water Drainage and Traffic Improvements, North Las Vegas	Categorical Exclus.	Approved 8/16/91
NV-91-039	Transuranic Waste Pad Cover, Area 5	Categorical Exclus.	Approved 11/11/91
NV-91-040	Install Laser Experiment Tank, Santa Barbara	Categorical Exclus.	Approved 10/24/91

Table 3.1 (NEPA Documentation - 1989-1991, cont.)

Document No.	Description	Category	Review Status
NV-91-041	Drilling of Adaptation Well, Area 20	Categorical Exclus.	Approved 10/24/91
NV-91-042	Soil Sample Collection for Soil Treatability Study, Area 11	Categorical Exclus.	Approved 10/07/91
NV-91-043	Treatability Studies for Contaminated Soil	Envisonmental Assmt.	At HQ, EM
NV-91-044	Onsite Inspection Agency Trailer Park, Area 6	Categorical Exclus.	Approved 9/4/91
NV-91-045	Postshot Equipment Maintenance Facility, Area 1	Categorical Exclus.	Approved 8/26/91
NV-91-046	Remove buildings at cement batch plant, Area 12	Categorical Exclus.	Approved 12/30/91
NV-91-047	Road repair and upgrade, Area 11	Categorical Exclus.	Approved 9/27/91
NV-91-048	Trench filling, Area 23	Categorical Exclus.	Approved 11/27/91
NV-91-049	High explosive grenade range, Area 23	Categorical Exclus.	Approved 12/4/91
NV-91-50	Underground munitions magazine, Area 5	Categorical Exclus.	Approved 12/4/91
NV-91-051	Cancelled		
NV-91-052	Waste compactors, Areas 6, 12, and 23	Categorical Exclus.	Approved 12/16/91

3.2 CLEAN AIR ACT

NTS activities conducted for compliance with the Clean Air Act included National Emissions Standards for Hazardous Air Pollutants (NESHAP) asbestos abatement projects and radiological reporting and monitoring for compliance with ambient air quality standards, as well as air quality permit issues which were addressed both at non-NTS sites (EG&G/EM facilities) and onsite.

3.2.1 NTS OPERATIONS

Clean Air Act compliance requirements were limited to asbestos abatement (projects involving friable asbestos in quantities greater than or equal to 14.9 square meters [160 square feet] or 79.2 meters [260 linear feet]) and radionuclide monitoring and reporting under NESHAP. Compliance with asbestos regulations, radioactive emissions, and air quality permits are discussed below. There are no criteria pollutant or prevention of significant deterioration monitoring requirements for NTS operations.

3.2.1.1 NESHAP ASBESTOS COMPLIANCE

In January 1990 the state of Nevada, Division of Occupational Safety and Health, issued regulations (Nevada Revised Statutes [NRS] 618.760-805) requiring that all contractors intending to engage in asbestos abatement projects (involving friable asbestos in quantities greater than or equal to three square feet or three linear feet) in Nevada submit a Notification Form. This form was required by the Division ten days before beginning any work at an asbestos abatement project site. Notifications were also made to the EPA Region 9 in accordance with 40 CFR 61.145-146.

During 1991 one NESHAP notification was made to EPA Region 9 and two state of Nevada notifications were made. These notifications were for asbestos renovation and abatement projects in accordance with the requirements of 40 CFR 61.145-146 and NRS 618.760-805. Reynolds Electrical & Engineering Co., Inc. (REECo), collected and analyzed bulk, occupational, environmental, and clearance samples for these projects. The two areas are listed in Table 3.2.

In February 1992, one NESHAP state of Nevada notification was made. This notification was for an asbestos renovation and abatement project in Area 23, Building 725.

3.2.1.2 RADIOACTIVE EMISSIONS

NTS operations were conducted in compliance with the radioactive air emission standards of NESHAP. On August 7, 1990, EPA Region 9 requested a review of NTS operations with respect to compliance with 40 CFR 61, Subparts H and Q. NTS operations are subject to Subpart H only. In compliance with reporting requirements, the DOE/NV provides reports to DOE/HQ on radioactive effluents for submission to EPA. Copies of DOE Orders 5400.1 and 5400.5, along with reports submitted to the DOE/HQ, were sent to the Region 9 Air and Toxics Division Director to indicate the requirements the DOE/NV must currently meet.

There are three locations on the NTS where effluents may occur from permanent stacks. These include air ventilation exhaust stacks (1) on the tunnels in Rainier Mesa, (2) on clothes dryers for the anti-contamination clothing laundry facility (although most of the radioactivity removed from this clothing is in the wash water), and (3) for the analytical laboratory hoods in Mercury. Based on the amount of material handled, the exhaust from the laundry and the analytical laboratories are considered negligible compared to other sources on the NTS. Sources that are difficult to monitor include increases in seepage of noble gases through the ground caused by meteorological changes, evaporation of tritiated water from containment

Table 3.2 NESHAP Notifications to the state of Nevada for NTS Asbestos Activities - 1991

Area	Building	Friable Asbestos	Date
26	2203	1070 lin. ft. of pipe	
	2204	insul. & 80 ft^3 vessel	
	2205	insul (EPA Reg. 9 notified)	Dates N/A
23	725	33 lin. ft. pipe insulation	Feb. 1992

ponds, and resuspension of plutonium contaminated soil from safety test sites. Other emissions occur from operational activities such as drillbacks into test cavities (to obtain diagnostic and other data) and purging of tunnel systems after nuclear tests (to facilitate re-entry activities). The NTS user laboratories that conduct these nuclear tests have developed effluent monitoring procedures that are accurate within a factor of two for such operational activities. Considering the low levels of maximum offsite exposures that have been reported in the recent past, this accuracy has been considered acceptable. For example, using best estimates of air emissions in 1991 as input to CAP88-PC the maximum individual effective dose equivalent was only 8.6×10^{-3} mrem, much less than the 10 mrem specified in 40 CFR 61.

Exposures to offsite individuals, either by monitoring or by CAP88-PC calculation, are much less than one percent of the 10 mrem/year limit. Discussions with EPA Region 9 personnel continue in order to determine (1) the acceptability of the present effluent monitoring for operational releases or (2) the modifications that may be necessary to achieve full compliance with 40 CFR 60 and 61 requirements. At EPA's request additional meteorological data for effluent sources on the NTS are being supplied for the NESHAP annual report.

3.2.1.3 AIR QUALITY PERMITS

NTS air quality regulatory compliance activities for this reporting period involved state of Nevada air quality permit reporting and renewals. (See Table 4.2, Section 4.3.1 for a listing of permit renewals.) Common air pollution sources at the NTS included aggregate production, stemming activities, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities.

The 1990 annual report for state of Nevada air quality permits was submitted to the state on April 15, 1991. This report included aggregate production, operating hours of permitted equipment, and a report of all surface disturbances of five acres or greater.

Visible emissions readings from air pollution sources were obtained to determine compliance with the state-regulated 20 percent opacity limit. Certification to perform visible emissions evaluations is required by the state, with recertification required every six months. During 1991, five REECo personnel were certified and/or recertified.

State air quality inspections of NTS facilities were conducted in May and July of 1991. During the May inspection, additional permits were recommended for portable equipment located in Area 1. These permits were obtained in September and are described in Section 4.3.

During the July inspection, the following items were addressed:

- An Order was issued for the Area 12 Batch Plant to install a spray bar on the aggregate hopper by October. With the state's approval, sprinkler heads were installed on the aggregate piles instead of the hopper. This was completed by October. A final closeout report was submitted documenting that visible emissions were less than 20 percent in November.

- A Notice of Violation was issued for the portable storage bins operating at the Area 12 Batch Plant. Emissions from the bins during the inspection approached 100 percent opacity at times. As required by the state, a new dust collection system was installed for the portable bins. In January 1992, state inspectors observed and approved the

new system during its operation. Visible emissions were well below 20 percent. A final report is being prepared to submit to the state through DOE/NV.

- A permit was recommended for the Two-Part Epoxy Batch Plant in Area 3. The application for this permit was submitted to the state on December 27, 1991.

The Air Quality Permit (OP 2276) for the Area 1 Aggregate Plant was renewed and issued by the state on February 12, 1992.

The state issued Air Quality Permit to Construct No. 2988 on March 10, 1992, for a Two-Part Epoxy Batch Plant.

On March 13, 1992, the state responded to a request for modification of Air Quality Operation Permit No. 1977, Area 12 Batch Plant. The modification has been approved pending the submission of required fees.

On March 3, 1992 REECO contracted The Mark Group, Engineers & Geologists, to do a fugitive dust study of permitted equipment and surface disturbance operations.

3.2.2 NON-NTS EG&G/EM OPERATIONS

3.2.2.1 RADIOLOGICAL REPORTING

There are no activities at any EG&G/EM operations that produce radioactive effluents. Clean Air Act issues affect only the nonradiological emissions covered by local permit requirements.

3.2.2.2 AIR QUALITY PERMITS

Air quality permits were required for three of the eight non-NTS, EG&G/EM operations although there were no effluent monitoring requirements associated with these permits. Specific compliance issues are discussed below.

Eighteen emission units at the EG&G/EM, Las Vegas Area Operation, North Las Vegas Facility (NLVF) and Remote Sensing Laboratory (RSL) were permitted with the Clark County Health District, Las Vegas, Nevada during 1991. The emission units were either registered under existing or new permits. A growth allowance was also negotiated which allowed EG&G/EM, LVAO, to add new emission units without going through the permit application process.

EG&G/EM, Amador Valley Operations (AVO) filed permit applications with the Bay Area Air Quality Management District for five solvent cleaning operations. These were existing operations that became subject to new regulations in 1991. Local air pollution regulations required businesses to discontinue use of aerosol spray paints containing more than 67 percent organics. Compliance has been maintained although no routine monitoring activities were mandated to verify compliance with this regulation.

EG&G/EM, STL was issued an Authority to Construct permit from the County of Santa Barbara, Air Pollution Control District, for a vapor degreaser.

EG&G/EM, WCO was required by local regulations to ensure that no more than one ton per year of 1,1,1-trichloroethane be used in vapor degreasers. Compliance has been maintained although no routine monitoring or reports were mandated to verify this requirement.

3.3 CLEAN WATER ACT

There are no National Pollutant Discharge Elimination System (NPDES) permits for DOE/NV facilities as there are no wastewater discharges to onsite or offsite surface waters. The state and DOE/NV will meet early in 1992 to discuss applicable permit requirements for storm water discharges. Monitoring and reporting were limited to the requirements of state and local permits. A complete listing of these permits appears in Section 4.3.

A Notice and Finding of Alleged Violation was issued by the state of Nevada to the Department of Energy and the Defense Nuclear Agency for violation of NRS Chapter 445.221 and NAC Chapter 445.179. The violation involves the modification of tunnel wastewater ponds at U12n Tunnel and the lack of a discharge permit for the same ponds. Response to the alleged violation must be made on or before April 20, 1992.

The Operations and Maintenance Manual (O & M) for the Area 23 Sewage Lagoon was approved by the state in March 1992. Presently the O & M manuals for other NTS sewage lagoons are being modified to match the approved manual. They will subsequently be submitted for state approval.

On February 5, 1992 the state rescinded a requirement for analysis of pH in state approved laboratories. At the NTS this rule previously affected required monitoring of permitted NTS sewage lagoon systems.

Tentative approval was given by the state regarding maintenance of the three foot minimum depth requirement in NTS sewage lagoon systems. The state requested further information on March 4, 1992, to verify sufficient biomass and odor abatement in lagoons which do not meet the three foot minimum depth. Further, this information must be included in revisions to sewage lagoon O & M Manuals.

3.3.1 NTS OPERATIONS

Water monitoring at the NTS was limited to sampling wastewater influents to lagoons and ponds under a series of state of Nevada permits. The results of this sampling are summarized in Section 7.1.2 of this volume. Other compliance issues are discussed below.

As part of planned actions for Tiger Team Finding SW/CF-3, an investigation was conducted to determine which abandoned septic tank systems at the NTS can be closed using state regulations and which systems need to be sampled for potential hazardous/radioactive contamination. Because these systems were abandoned, detailed knowledge of disposal activities are not available. SW/CF-3 listed 30 abandoned systems from a 1987 report. During the course of the investigation, a total of 44 systems were eventually identified. Of these 11 were scheduled for closure by the Environmental Restoration Program. The remaining 33 systems included 10 which were still active or soon to be reactivated, 16 which will require sampling prior to closure, five which can be closed without sampling, and two systems which required further investigation. A sampling plan for these systems will be developed, and initial closure activities are scheduled for 1992.

A survey of active septic systems, completed in January 1991, in response to Tiger Team Finding SW/CF-5, revealed 37 active systems with state requirement's deficiencies. Corrective actions have been assigned to responsible department managers.

On June 4, 1991, the state denied a request to use three sewage lagoons (Area 12, Area 23, and Area 6-Yucca Lake) for disposal of septage pumped from portable toilets on the NTS. The state asked that DOE/NV demonstrate that the discharge of septage material would not be harmful to the sewage lagoon or establish an alternate method of septage disposal. A 90 day response period (by September 4) was established by the state. Sampling to determine biological and chemical parameters was initiated, and engineering calculations were prepared to substantiate that no adverse conditions existed. A report outlining the results of the study was transmitted to the state on October 21. On October 25, the state extended permission to continue septage hauling and disposal, while they reviewed the submitted report. On October 28, approval for disposal of septage in the lagoons was given to DOE/NV.

On January 28, the state conducted an inspection of all discharge permits at the NTS. These permits are for sewage lagoon systems in Areas 2, 6, 12, 23, and 25. No permit violations were noted and the state reported that "the facilities are all being well maintained and are in very good condition". The state in its report issued on February 6, also gave approval to "not inspect a site if there is no flow to the facility". Previously, weekly inspections by the operator were conducted even though some facilities received no flow (these are currently inactive sites).

A final draft of the Operations & Maintenance Manual for the Area 23 Sewage Lagoons was transmitted to the state for approval on November 25. Subsequent to state approval, the remaining manuals for other NTS sewage lagoons will be modified to match the approved manual. This draft incorporates state comments received earlier in 1991.

3.3.2 NON-NTS EG&G/EM OPERATIONS

Permits for wastewater discharge were held for five of the eight non-NTS, EG&G/EM-operations, and monitoring and reporting were accomplished according to the dictates of state and local governments. No wastewater permits were held for the Los Alamos Operations, or Washington D.C. Aerial Measurements Department in 1991. No noncompliance level of any regulated substance was reported to any permitting agency.

EG&G/EM, LVAO submitted Baseline Monitoring Reports to local regulatory authorities for the North Las Vegas Facility and the Remote Sensing Laboratory. New wastewater permits were issued for these facilities.

EG&G/EM, SBO received a notice of violation from the Goleta Sanitation District (GSD) for exceeding the facility discharge concentration limit for zinc identified during a routine GSD surveillance of SBO facility effluent. Subsequent samples taken showed the zinc concentrations below the allowable release levels. The release of zinc to the sewer resulted from subcontractor work being done by the landlord of the facility.

EG&G/EM, KO secured a new wastewater discharge permit on November 5, 1991 for the alodining shop effluent at the Craddock facility.

EG&G/EM, Amador Valley Operations wastewater discharge permit number 3671-101 was revised to a zero discharge status on February 27,1992.

3.4 SAFE DRINKING WATER ACT

Safe Drinking Water Act regulations apply to onsite potable water sources at the NTS and an injection well at the EG&G/EM facility in Woburn, Massachusetts. Permit information and the associated required monitoring are discussed in Section 4.3.

Further revisions to the Sample Siting Plan for the NTS and TTR were requested from the state on January 8, 1992. These revisions were made and the plan was resubmitted to the state in March.

A water sample collected at the Area 3 Cafeteria on February 7, 1992 was positive for total coliforms. Five repeat samples were collected on February 10 and 11, and the area posted to inform the public. Repeat samples were negative and postings were removed on February 14.

On February 19, 1992, another positive total coliform sample was collected at the Area 5 Cafeteria. Four repeat samples were taken on February 24 that tested negative. In March, six more samples were taken. These also tested negative. Postings were performed in accordance with state requirements.

A meeting was held on March 24, 1992, to discuss the future of water haulage at the NTS. In several areas, potable water is brought by trucks to storage tanks for distribution. In July 1991, several samples taken at the Area 6 fill stand indicated the presence of coliform bacteria. Recommendations include establishment or refurbishing of existing wells to provide service, modification of the fill stand, truck, and discharge pipe into a closed system, or the construction of distribution lines to areas serviced by water haulage.

3.4.1 NTS OPERATIONS

In 1991, REECo began a cross connection survey of all NTS buildings. This survey is the first step to address Tiger Team Finding SW/CF-2 and to meet state requirements for cross connection control. Three REECo personnel were certified as Cross Connection Control Program Specialists through the American Water Works Association, California-Nevada Section. Certification was earned by attendance of training courses offered at the University of Southern California by the Foundation for Cross Connection Control & Hydraulic Research and obtaining a passing score on a written examination. During 1991, more than 200 buildings on the NTS were inspected to identify deficiencies in cross connection control. The survey is scheduled to be completed in 1992.

A Sample Siting Plan for the NTS listing sampling locations and frequency was prepared and transmitted to the state on December 13,1990. State comments made on April 16, 1991 to the plan are as follows:

Comment: The population count on those recently issued permits do not correspond to the counts stated in the Sample Siting Plan. There is also a discrepancy as to whether the system is a community or a noncommunity system. This information is necessary in order for the correct amount of samples to be taken according to the Safe Drinking Water Act.

Response: The "Report of NTS Related and Other NV Related Employment" for April, 1991 was used to determine the number of people in Mercury and in the Forward Areas. The

population is very close to that listed in the Sample Siting Plan. The population estimates based on the April report are included in Table 3.3.

The Safe drinking water Act requires two bacteriological samples per month be taken for systems serving between 100 and 2500 people. The populations for two systems, permit numbers 4099-12C and 5000-12 NC, serve close to 1000 people and have been listed as greater than 1000 to assure proper sampling frequencies, (i.e, twice per month).

The water systems for permits 360-12C, Area 23, and 4099-12C, Area 12, are the only community water systems. The Area 23 system serves a permanent population of approximately 600 and the Area 12 system serves a permanent population of approximately 400 according to the REECo Housing Office. A list of the community and noncommunity systems is included in Table 3.3.

Comment: Please state the well numbers that serve each of the public drinking water systems on the NTS.

Response: The wells serving the public drinking water systems are shown in Table 3.3.

Comment: Please state why Well 8 is sometimes inoperable.

Response: The water distribution map for Area 12 states: "Well 8, located in Area 18, is presently the only source of water for Area 12. Whenever Well 8 is inoperative, water must be hauled from other areas."

The well has only been inoperative when pump replacements are necessary. Because the water storage capacity for the system is 450,000 gallons, water haulage has not been necessary during repairs.

Table 3.3 Well, Population, and Community/Noncommunity Status Information for Public Drinking Water Systems at the NTS - 1991

Permit No.	Area(s)	Population	Status	Wells
360-12C	22, 23	1500	Community	5C, Army
4097-12NC	03	200	Non-Community	C, C1, 4
5000-12NC	06, 27	1000	Non-Community	C, C1, 4
4098-12NC	25	200	Non-Community	J12, J13
4099-12C	02, 12	1000	Community	8
5024-12NC	01	200	Non-Community	UE16d

NOTE: The population for permits 4099-12C and 5000-12NC have been rounded up to assure proper sampling frequency.

Comment: Please note that NAC 445.410.4 requires the end of all water lines larger than 1.5 inches to be equipped with a blow off. Therefore, the water lines that have been capped, if they are larger than 1.5 inches, will need to have a blow off installed.

Response: A survey will be made by inspections and engineering drawing reviews to determine if there are any capped lines which will require a blow off. Any modifications will be reported to the state.

The Sample Siting Plan was further modified in December of 1991, to include another water haulage truck.

The state of Nevada inspected the public water system on the NTS during the period of May 21 to May 24, 1991. As a result, the state made 71 recommendations for corrective actions ranging from repainting storage tank access covers to supplying respirators at chlorination rooms. A corrective action plan has been developed to address the recommendations. As of December 16, 1991, 39 items have been corrected. The remaining 32 are in various stages of engineering and/or budget analysis.

On July 25 DOE/NV issued a Stop Work Notice for water hauling trucks at the NTS due to microbial water contamination. NTS procedure requires that each load of water be sampled for coliform bacteria. Positive results were reported for three of four sampling days (July 16-19) from trucks using the Area 6 fill stand. On July 19, water hauling was suspended and the trucks were superchlorinated over the weekend. Also on July 19, samples were collected from the storage tanks and distribution systems served by the contaminated trucks (these were negative for coliform bacteria). The rubber boot on the fill stand was also replaced. The Area 23 fill stand was used from July 22-25, when all water hauling ceased. The state representative requested the following sampling:

- Well C & C1, Area 6 - Prior to the chlorinator
- Rubber boot at Area 6 fill stand
- 2 - good samples from each truck on consecutive days
- 4 - samples from every location that was serviced by the trucks

Samples were collected from the wells and water usage at serviced area was suspended on July 24, for drinking and body contact. Storage tanks were chlorinated to 5 ppm. After negative results were obtained for all samples requested by the state, service was restored on July 30.

In November 1991, the Army Well servicing Areas 22 and 23, experienced pump failure. Notification and approval from the state prior to and during repair activities was initiated through DOE/NV. Subsequent to repairs and sampling, the state gave approval on December 9, to place the well back in service.

3.4.2 NON-NTS EG&G/EM OPERATIONS

The EG&G/EM facility in Woburn, Massachusetts, has an injection well for discharging uncontaminated, noncontact cooling water to the ground. The local division of the Massachusetts Department of Environmental Protection has been contacted to secure the appropriate permit for this discharge. The permitting process was put on hold until a State Engineer could conduct a site visit and provide permitting guidance. Ground water monitoring

may be required when the permit is issued. There are no other noncompliance issues for any other non-NTS, EG&G/EM operation.

3.5 RESOURCE CONSERVATION AND RECOVERY ACT

In addition to routine environmental sampling (discussed in Section 7.1), significant RCRA activities for 1991 included (1) state of Nevada RCRA inspection of the Area 5 RWMS and Area 12 tunnels, (2) revisions of the Part A and Part B permit applications, (3) hazardous waste reporting, (4) cleanup of abandoned wastes, (5) underground storage tank closure, and (6) revision of waste minimization and pollution prevention awareness plans. These items are discussed in detail in the following paragraphs.

The required 1991 Hazardous Waste Generator Report for Generator Identification Number NV3890090001 was sent to the state of Nevada on March 31, 1992.

State of Nevada RCRA inspectors visited the Area 5 Radioactive Waste Management Site and Hazardous Waste Accumulation Site six times in the first quarter of 1992. The dates of these visits were January 16, 30 and 31, February 13 and 24, and March 4. No reports have been submitted by the state concerning these visits.

A Finding of Alleged Violation (FOAV) and Order was issued by the state of Nevada on March 31, 1992. The Finding and Order relate to the Department of Energy's and Reynolds Electrical & Engineering Co., Inc.'s failure to comply with NRS 459.515 and NAC 444.8632. The violation centered around 11 drums of soil which had been inspected by the state on January 22, 1992. The drummed soil represented drill cuttings in which laboratory analyses indicated the presence of small amounts (parts per billion) of methylene chloride and toluene, common laboratory contaminants. The drill cuttings were accumulated in August 1991. Laboratory results were evaluated and a request to dispose of the drums was made in September 1991. On October 4, 1991 DOE/NV and the REECo Waste Management Department (WMD), agreed to leave the drums in place until a decision involving their deposition could be made. On March 17, 1992, DOE/NV instructed WMD to move the drums to the Area 3 CNC-11, a temporary waste storage area. After further review of the data the REECo Environmental Compliance Office and the WMD determined that the drums contained nonregulated waste. On March 28, 1992, it was recommended to DOE/NV that the drums be sent to U10c Sanitary Landfill for disposal. Soil will be disposed of at the landfill subsequent to state review of the data submitted by DOE/NV and REECo in response to the FOAV and Order.

On January 22, 1992, the state of Nevada issued to DOE/NV and REECo written notice that it was assessing a penalty of $20,000 for an FOAV issued to DOE/NV and REECo in June 1991. The determination resulted form the state's analysis of information presented during an August 1991 enforcement conference and provided later in response to requests for additional information. In summary, insufficient samples of Rocky Flats pondcrete had been taken to account for waste stream variability; furthermore, the samples were not random. Also, insufficient or improper samples were taken to certify compliance with land disposal restriction standards. The state's analysis appears to be appropriate and reasonable since a fine in excess of $1 million could have been calculated based on the numbers of shipments of mixed waste that were received at NTS. Further legal and administrative details remain to be worked out between DOE and the state.

Since early January 1992, the draft settlement agreement (jointly prepared by Office of General Council, Office of Environmental Restoration and Waste Management, and DOE/NV elements) to resolve issues related to the November 9, 1990 FOAV and Order regarding storage of TRU mixed waste at the NTS has been acceptable to the state of Nevada officials. The agreement allows DOE/NV to retain the existing inventory of mixed TRU waste subject to an appropriate permitting process. On February 13, 1992, DOE/NV provided a revised letter that addressed the state's concerns; and the state has expressed its willingness to sign the agreement. The Settlement Agreement is in the HQ's review/approval process.

3.5.1 STATE OF NEVADA/RCRA ACTIVITIES

On May 1, 1991, the Nevada Division of Environmental Protection (NDEP) conducted a RCRA compliance inspection. The following items were a result of this inspection:

Description: As a result of an August 1990 inspection, the state issued on November 1, 1990, a finding of alleged violation (FOAV) related to TRU waste management operations. The state cited the operation of the TRU storage pad without interim status. The letter required information of the waste and removal of any TRU mixed waste to a permitted facility.

Status: On November 29, 1990, a response was sent to the state that interim status had been properly obtained and a plan was provided to characterize the TRU waste and to manage that which was determined to be mixed waste. On January 18, 1991., the state provided guidance on the characterization process and reiterated the order to remove mixed TRU waste. On April 22 1991, waste inventory data was provided on the TRU waste suspected of being mixed. A compliance agreement was requested to bring the storage pad into compliance with RCRA standards. Labels were place on the drums and the drums were placed in RCRA storage configuration. On June 3, 1991, the state responded to the inventory by reiterating its order to remove the waste. A hearing was held with the Nevada SEC and an out-of-court solution is currently being negotiated.

Description: NDEP issued an FOAV on June 24, 1991. The FOAV stated that the transuranic (TRU) mixed waste storage facility was reconstructed without having a permit or interim status, and that the capacity of the storage area was expanded in 1988 without prior state approval. This was also mentioned in the FOAV and Order issued in November, 1990.

Status: A hearing was requested and is before the Nevada State Environmental Commission (SEC).

Description: On June 23, 1991, an FOAV was issued relating to mixed waste management operations. Waste acceptance was to cease until an analysis plan to test land disposed waste as required by 40 CFR 268.7, had been approved by DOE/NV. This issued had been identified in a November 1990 letter from the state.

Status: No mixed waste has been received since May 1990. A Waste Analysis Plan was submitted in April 1991 in response to the November 1990 letter. State comments were received in July 1991. additional information was requested by the state at an enforcement conference held on August 8, 1991. Except for information that must be submitted by the generator (Rocky Flats Plant), all requested information was sent to the state on August 21, 1991. The remaining information was sent to the state on September 30, 1991.

A second state inspection was conducted on September 24, 1991. No findings were reported from this inspection.

3.5.1.1 RCRA PART A & B APPLICATIONS

During 1991 Raytheon Services Nevada (RSN) began revising and updating the original Part A and Part B Applications which were submitted to the state in 1988.

The Part A Application was extended through meetings with REECo and other NTS personnel to identify numerous potential RCRA waste units. The mixed transuranic (TRU) waste stored at Area 5 was reinventoried and discrepancies in waste code labeling were corrected. New photos were also obtained for the Part A.

The Part B Application will now include all active and proposed mixed waste storage and disposal units in the Area 5 Radioactive Waste Management Site. These are Pit 3, Trench T-4C, the TRU Waste Storage Pad, and the proposed 18 cell Min-Tech Landfill. The Hazardous Waste Storage Unit in Area 5 and the Area 11 Explosive Ordnance Disposal Site will also be added. Original background material will be verified and updated to rectify deficiencies noted by the state. Engineering drawings will reflect new design information.

3.5.2 HAZARDOUS WASTE REPORTING NTS AND NON-NTS, EG&G/EM OPERATIONS

DOE/NV has been allowed to dispose of waste under the EPA Generator Identification (ID) Number NV3890090001 which has been assigned to REECo, the primary contractor for the NTS. The required hazardous waste generator annual report was sent to the state of Nevada on March 30, 1990. EG&G/EM, LVAO sent a 1990 hazardous waste generator annual report to the state of Nevada on March 11,1991 for the LVAO waste associated with EPA Generator ID Number NVD097868731 and on 2/28/92 to DOE/NV for 1991 hazardous waste activities. A response to the Congressional Inquiry concerning the procurement process for offsite waste contractors was provided to DOE/NV Defense Waste Operations.

3.5.3 PAHRUMP WASTE CLEANUP

The state of Nevada requested assistance from REECo to cleanup abandoned waste at 2291 Blosser Ranch Road, Pahrump, Nevada. The site consisted of 780 containers of various size, most of them 55-gallon drums. Most containers were stored on wooden pallets. A REECo stamp was found on three 5-gallon buckets. Three of the containers bore a Defense Logistics Agency stamp; the other containers bore no discernable labels to indicate ownership. A region IX U.S. Environmental Protection Agency Technical Assistance Team performed field compatibility tests on much of the waste and assigned each container to a compatibility group. The four groups established by the team were flammable liquids, flammable solids, noncharacteristic liquids, and noncharacteristic solids.

Clean-up activities began on September 21, 1990. Most of the 55-gallon drums, all 1-gallon cans, and many 5-gallon buckets were overpacked. The containers that were not over packed were fit for transport.

After overpacking, the crew excavated waste which had spilled onto the ground. The spilled material was placed in a salvage drum and labeled as "unknown soil". Soil samples from the excavation sites were collected to verify no infiltration of the waste.

The waste was moved to the NTS over a period of two days on flatbed trucks. The waste was staged in a fenced and posted yard in Mercury. Flammable and nonflammable drums were placed in separate section in the yard, which was lined with a double layer of plastic sheeting anchored by sandbags.

The majority of the material was classified as waste paint, flammable liquid. This material was removed from the NTS in December 1990 and transported to Oil Process Company in Los Angeles, California and later to Rollins Environmental Services, Inc., in Texas for incineration. Five salvage drums containing pieces of wooden pallets on which the drums were originally stored in Pahrump were removed in December. Liquid nonhazardous material, that could not be solidified, was also transported to Oil Process Company and incinerated at Rollins. Nonhazardous solid material was disposed of in an approved Class I Sanitary Landfill on the NTS.

The soil sample data indicated that soil in the yard and in surrounding areas at Blosser Ranch Road is presently comparable to pre-paint storage conditions, and no further cleanup is required. The Pahrump homeowner has full use of the property.

A final report from REECo was submitted to DOE/NV in June, 1991, for transmittal to the state of Nevada.

3.5.4 UNDERGROUND STORAGE TANKS

3.5.4.1 NON-NTS EG&G/EM OPERATIONS

Onsite remediation began on January 1, 1992 at the Remote Sensing Laboratory where 500 gallons of fuel were released into the area surrounding the underground storage tanks on April 25, 1991. The tanks were pulled and the soil was excavated down to 14 feet below grade. It was discovered that soil contamination extended beyond 22 feet and would required remediation by some means other than excavation. A purchase requisition was issued for the development of a site characterization work plan to determine the horizontal and vertical extent of the contamination and provide a conceptual evaluation of remedial action alternatives.

3.5.4.2 NTS OPERATIONS

Twenty-four underground storage tanks (USTs) containing petroleum products were removed, closed in place, or temporarily closed in 1991 (see Table 3.4) in accordance with state statutes. In addition 17 tanks were temporarily closed in 1991 while awaiting upgrades.

As part of the 1991 tank activities, all tanks to be upgraded had soil samples taken from the tank ends to identify any soil contamination prior to redesign and construction. To date, overfill releases from tanks located at the Area 6, 12, and 23 Gasoline Stations were observed and necessitated additional soil sampling. All tanks that were planned to be upgraded (except a tank containing asphaltic material) were also pressure tested for leaks. All tanks were reported to have passed the test at a leak rate of 0.2 gallons per hour.

Table 3.4 Underground Storage Tank Activities - 1991

Area/Facility	Tank Number	Action Taken
23/Fleet Operations	23-751-5	Removed
	23-751-6	Removed
	23-751-7	Removed
22/Desert Rock Airstrip	22-DRA-4	Removed
6/CP-150	6-CP-150	Removed
6/CP-162	6-162-1	Removed
	6-162-2	Removed
	6-162-4	Removed
25/Service Station	25-4838-1	Removed
	25-4838-2	Removed
	25-4838-3	Removed

A computerized data base was prepared for the 115 tanks at NTS. Because the number of tanks and documentation of the tanks was ambiguous, REECo submitted revised tank notification forms to DOE/NV for all tanks containing hydrocarbons known to be at NTS.

Additional effort was made to identify undocumented USTs. Approximately 20 tanks were identified at this time. The Nevada Division of Environmental Protection will be notified of these tanks once this new information has been verified.

As part of the upgrading of the Area 23 Gasoline Station in Mercury, in-tank monitors were installed for monthly tank gauging. This equipment will also be placed in tanks in the Area 6 and Area 12 Gasoline Stations.

3.5.5 WASTE MINIMIZATION

3.5.5.1 NTS OPERATIONS

The DOE/NV Waste Minimization and Pollution Prevention Awareness Plan was augmented, updated, and published in June 1991. The REECo Waste Minimization and Pollution Prevention Awareness Implementation Plan for CY 1992 was published December 15, 1991. The REECo Implementation Plan follows the format of the DOE/NV Plan. These plans apply to hazardous, radioactive, mixed, and solid wastes.

The REECo Implementation Plan updated waste stream information through the completion of waste minimization surveillances of operations. These surveillances will be done annually. The Implementation Plan also provides a schedule for Process Waste Assessments. These assessments are designed to systematically identify waste minimization opportunities and implement the most effective technologies and techniques.

All REECo quantitative goals and schedules were met. Total NTS hazardous waste generation was reduced by seven percent compared with 1990, and over 45 percent when compared with 1989 amounts. The total NTS solid waste generation was reduced by nine percent in 1991 compared with the 1990 amount.

Over 90 percent of NTS stock items that had the potential to generate a hazardous waste in normal use were eliminated from warehouse stores. In addition over 75 percent of stock items were replaced under Just-In-Time contracts. Just-In-Time items were pre-approved for use by the REECo Environmental Compliance Office (ECO). Potentially hazardous waste generating items were eliminated from these contracts, as was excess inventory of supply items that could lead to waste generation. The ECO continued its procedure of pre-approving REECo special order purchase requisitions to minimize orders of potentially hazardous waste producing products. The ECO also continued its manual (computer aided) tracking of the final disposition of stock items that have the potential to create a hazardous waste in normal use.

Significant new waste minimization technologies implemented in 1991 include:

- Closed loop steam cleaning (1 unit) - eliminates oily waste
- Paint thinner recycling (2 units) - distills thinner for reuse
- Oil filter crushing (3 units) - reduce disposal volume, reclaim oil

The following 10 items were recycled by REECo in 1991:

- Paint thinner; Dye tool coolant; Freon; Used oil; Kitchen oil; Toner cartridges; Lead acid batteries; Cardboard; Aluminum; and Paper

Employee training and awareness efforts are referenced in the REECo Implementation Plan. These include the use of training films and other pollution prevention awareness media. The initial media campaign was conducted using posters and check stuffers in 1991. An employee training course was developed as well. Waste minimization technology transfer with line personnel and with other organization in the DOE system was continued. Product and technology research is ongoing.

3.5.5.2 NON-NTS EG&G/EM OPERATIONS

Policies and Procedures

The EG&G/EM Waste Minimization and Pollution Prevention Awareness Implementation Plan was submitted to DOE/NV on December 20, 1991. The plan describes EG&G/EM waste minimization policy, objectives and goals. A formalized system of waste minimization was developed through the implementation of EG&G/EM Policy No. 31-02, Minimization of Waste Paper, Plastic, and Cardboard; Policy No. 31-04.A, Minimization of Hazardous Waste; and Standard Operating Procedure No. 31-006.A, Hazardous Waste Minimization Plan. All EG&G/EM operations were required to evaluate waste generating processes for product substitution, cross-contamination control, or site treatment. Viable minimization activities were identified and prioritized for implementation.

Training

Almost 2,000 EG&G/EM employees received Environmental Awareness training in 1991 in an effort to enhance employee awareness of environmental issues and the importance of considering pollution prevention at every level within the company.

Product Substitution

EG&G/EM has made some progress towards substituting chemicals that have a high stratospheric ozone depletion potential with chemicals that have a lower depletion potential. Most air conditioner refrigerants at EG&G/EM facilities have been substituted with HCFC-22 which has a reduced ozone depletion potential of 0.05 as opposed to CFC-11 and CFC-12 which have an ozone depletion potential of 1.0.

Substitutions for 1,1,1-trichloroethane have either been implemented or are in the trial phase. Planisol is being used as a replacement for gross non-critical cleaning. Irradicon is being used on a trial basis as a supercritical cleaner.

The sheet metal shop at the EG&G/EM, NLV facility has replaced solvent based paints with water base paints for most applications reducing the solvent waste stream from this facility by 250 gallons per year.

Recycling

Freon recycling systems have been used for air conditioning systems EG&G/EM operates and maintains which are capable of capturing, cleaning and drying the freon for reuse. EG&G/EM has also implemented a recycling program for HP Laser Jet II/III and Canon FAX toner cartridges.

Treatment/Volume Reduction

During 1991, EG&G/EM, LVAO, permanently discontinued the printed circuit board plating operations at the North Las Vegas Facility. A batch wastewater treatment unit was used to neutralize acidic and alkaline plating baths and precipitate heavy metals. The wastewater was discharged to the publicly owned treatment works (POTW) after testing to confirm the effluent met permitted discharge standards and the filter cake was managed as hazardous waste. This treatment process reduced the hazardous waste stream by 6 cubic yards.

The EG&G/EM, Remote Sensing Laboratory, has a photo laboratory which develops 850 square feet of film per day. The effluent from the laboratory processes is captured, neutralized, and the silver removed before it is discharged to the POTW. The effluent is tested 4 times a day to verify it is within the permitted discharge limits. All other waste minimization activities reported for 1990 continue to be effective for 1991.

3.6 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA)

3.6.1 NTS OPERATIONS

In 1987 a DOE/HQ task force determined that underground nuclear device testing areas are CERCLA sites. Under CERCLA all releases of hazardous or extremely hazardous substances that exceed reportable quantities must be reported to the National Response Center (NRC). Following further review of the issue and reporting procedures by the DOE/NV and EPA, the DOE/NV began reporting nuclear tests to the NRC in 1989. This reporting is in accordance with Section 103 of CERCLA and Section 304 of SARA. Following a test the NRC is notified of the test and of which typical test profile to reference. During 1991 the DOE/NV continued reporting underground tests to the state of Nevada, Emergency Management Division, as part of this reporting procedure.

Preliminary Assessment/Site Investigation reports required by CERCLA were prepared for the NTS and for formerly used sites and provided to the EPA in 1988. Due to changes in the Hazard Ranking Score system, a hazard ranking score (HRS) package assigning a proposed HRS score to the NTS was submitted to U.S. EPA in September 1991.

The possibility of listing the NTS on the NPL of hazardous waste sites under the auspices of CERCLA carries potential for extensive budget and operational impacts. During 1991 environmental restoration planning for environmental contamination mitigation and environmental restoration actions was continued.

A SARA Tier II report was filed with the DOE/NV on February 25, 1991, for the NTS.

The SARA Tier II report for the NTS was still in draft form as of March 31, 1992. Delays ere due to state revisions to the federal forms which were not distributed until late in March.

3.6.2 NON-NTS EG&G/EM OPERATIONS

A Tier II report was filed with the DOE/NV on February 21, 1991, for the LVAO North Las Vegas Facility (a Form R report was not required), and four Tier II reports were filed on March 6, 1991 for fuel storage facilities managed by the Remote Sensing Laboratory. A Tier II report was prepared and submitted for EG&G/EM, WCO on June 25, 1991. A Form R report was prepared for Woburn Operations and submitted to the DOE/NV on June 6, 1991.

A Tier II report was filed with the DOE/NV on February 26, 1992, for the LVAO North Las Vegas Facility, and four tier II reports were filed by March 2, 1992, for fuel storage facilities managed by the Remote Sensing Laboratory. A Tier II report was prepared and submitted for EG&G/EM, WCO on February 13, 1992.

3.7 TOXIC SUBSTANCES CONTROL ACT

The Toxic Substances Control Act requires submission of an annual report describing polychlorinated biphenyl (PCB) control activities. The NTS PCB annual report was transmitted

to EPA in June, 1991. The report included the quantity and status of PCB and PCB Contaminated transformers and electrical equipment at the NTS. Also reported were the number of shipments of PCBs and PCB Contaminated items from the NTS to an EPA approved disposal facility. By the end of 1991, all known PCB transformers had been either reclassified or appropriately disposed of, and three PCB Contaminated transformers and regulators were under the 90 day period for reclassification. Successful reclassification of these three PCB Contaminated transformers will complete the reclassification or disposal of all known PCB and PCB Contaminated transformers at the NTS.

3.8 FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

During 1991 REECo was responsible for the application of pesticides at the NTS. The program was operated under the supervision of a company sanitarian who was certified as a pesticide applicator with the state of Nevada. The program consisted of application, training, record maintenance, and scheduling. No unusual environmental activities occurred in 1991 at the NTS relating to FIFRA.

Pesticides were stored in an approved storage facility located in Area 23. Pesticide usage included insecticides, herbicides, and rodenticides. Insecticides were applied twice a month at the food service and storage areas, herbicides were applied once or twice a year, and all other pesticide applications were applied on an as-requested basis. General-use pesticides were used for most applications, although restricted-use herbicides and rodenticides were used upon occasion.

Records were maintained on all pesticides used, both general and restricted. These records will be held for at least three years. Training activities include at least two safety meetings covering pesticide use, and all applicators are provided the opportunity to receive state-sponsored training materials.

Contract companies applied pesticides at all non-NTS facilities in 1991.

3.9 SOLID/SANITARY WASTE

In October 1991, solid waste disposal functions at the NTS were transferred from the Industrial Hygiene Department to the Waste Management Department.

3.10 ARCHAEOLOGICAL AND CULTURAL HISTORY PRESERVATION

The National Historic Preservation Act requires federal agencies to take into account any impact their actions might have upon historic sites listed in the National Register of Historic Places. In compliance with this law, the DOE/NV contracted pre-activity surveys and other studies to assess any impacts NTS operations may have on historical and archaeological sites found on the NTS. From the findings of the surveys, plans can be written for the recovery of data to mitigate the effects of operations on these sites. When the plans have been finalized, recovery programs may be initiated for the collection of archaeological data. The data recovery programs culminate in technical reports on the scientific findings of the programs. The responsibility for conducting these studies belongs to a group (Task 5 - Compliance with

Environmental Regulations/Archaeology) within the DOE/NV-sponsored Basic Environmental Compliance and Monitoring Program (BECAMP).

In 1991, 17 pre-activity surveys were conducted for archaeological sites on the NTS, and reports on the findings were prepared. These pre-activity surveys identified 56 sites containing previously unknown archaeological information. These sites were added to the cultural resources inventory files and site records, and all artifacts collected from the NTS were processed for storage. Due to avoidance of all potentially significant sites by activities at the NTS, no test excavations, data-recovery plans, or data-recovery projects were undertaken in 1991. Other efforts in 1991 included assisting DOE/NV in the management of cultural resources on the NTS, preparing management objectives and plans, and assisting in public relations and communication concerning the NTS archaeology program.

As part of the Programmatic Agreement with the Nevada Division of Historic Preservation and Archaeology and the Advisory Council on Historic Preservation, work continued on the long-range study plan for Pahute and Rainier Mesas. The objective of the plan is to study a geographically representative sample of all cultural resources on Pahute and Rainier Mesas. In 1991, six data recovery projects were initiated on Pahute Mesa.

Initiation of the American Indian Religious Freedom Act (AIRFA) Compliance Program occurred in 1989. The act directs federal agencies to consult with Native Americans to protect their right to exercise their traditional religions. The purpose of the NTS AIRFA Compliance Program is to assist DOE/NV in the development and implementation of a consultation plan designed to solicit Native American comments regarding the effects of DOE/NV activities on Native American historic properties and the expression of traditional Native American religions. The program requires (1) a literature review of baseline documents about Native American concerns on the NTS, (2) development of a study plan on how the DOE/NV is considering the effects of NTS operations on Native American concerns, (3) consultation with Native Americans who have concerns on the NTS, including coordinating field visits, (4) preparation of a draft report on the findings of the study plan and consultations with recommendations for mitigation of adverse effects on Native American concerns, and (5) completion of a final report which has been reviewed by appropriate state of Nevada and federal agencies. A literature review and evaluation of baseline documents about Native American concerns on the NTS were completed in 1990. This information was assembled in a draft baseline document and was used in the preparation of a draft study plan. In 1991 the final versions of these documents were completed and consultations with Native American tribes were initiated.

3.11 ENDANGERED SPECIES PROTECTION

The Endangered Species Act (ESA) requires federal agencies to assure that their actions do not (1) jeopardize the continued existence of state of Nevada and federally listed endangered or threatened plant or animal species or (2) result in the destruction or adverse modification of critical habitat for these species. In compliance with this law, the DOE/NV contracts pre-activity surveys and other studies to identify the locations and areas occupied by protected species. The responsibility for conducting these studies belongs to a group (Task 5 - Compliance with Environmental Regulations/Endangered Species) within the DOE/NV-sponsored BECAMP. Efforts in 1991 included identifying locations of the plant *Astragalus beatleyae*, work associated with the *A. beatleyae* conservation agreement (see below), and assessments of NTS activities on the desert tortoise, *Gopherus agassizii*.

There are currently 15 species of concern found on the NTS. Under the ESA, there are nine plant species that are being considered for listing as endangered or threatened and one reptile species that was listed (on an emergency basis) as an endangered species in 1989. This reptile species was relisted as a threatened species in April 1990. Five other species found on the NTS are protected by other regulations (i.e. Wild Horse and Burro Act).

During 1991, 50 pre-activity surveys were conducted to determine the presence of threatened or endangered species. Survey results and recommendations were documented in 46 reports. Significant survey findings included locations of potential habitats of the plant *A. beatleyae,* (two in Area 20 and three in Area 19), locating populations of the plant *Penstemon pahutensis,* (two in Area 19 and two in Area 12), and locating one population of the plant Cymopterus ripleyi *var. saniculoides* in Area 4. Baseline maps for updating federally listed Category 1 and 2 plant distribution maps were compiled.

Work associated with the *A. beatleyae conservation agreement* between the DOE/NV and the U.S. Fish and Wildlife Service (USFWS), signed in 1989 continued in 1991. The agreement includes (1) the preparation of a species management plan; (2) pre-activity surveys to identify and protect populations from disturbance; (3) implementation of field surveys to document species' life history, assess the viability of known populations, and locate new populations; (4) documentation of known populations on maps filed with the DOE/NV; and (5) fencing of the species' type locality.

A field study plan for monitoring *A. beatleyae* was prepared and implemented in 1989. Field monitoring in 1991 under the plan included the collection of monthly and annual microclimate and life history data from 13 *A. beatleyae* populations. Habitat characterization data were also collected and included site descriptions, plant species composition, and vegetative cover. Permanent sampling transects used to measure densities of *A. beatleyae* plants and nearest-neighbor distances were established at each site. Voucher specimens were collected to document the range of the plant on the NTS.

The USFWS listed the Mojave desert tortoise *(Gopherus agassizii)* as a "threatened species" north and west of the Colorado River in April 1990. The primary reasons for listing the desert tortoise were the continued loss of habitat and the rapid decline in tortoise numbers due to disease, habitat destruction by human activities, and other factors. In 1990 a USFWS permit, required for handling desert tortoises, and a state of Nevada scientific collection permit for the study of desert tortoises on the NTS were received by EG&G/EM. The desert tortoise distribution on the NTS is patchy and primarily in the southern third of the NTS. Larger numbers of tortoises appear to inhabit the bajadas surrounding Jackass Flats, Frenchman Flat, most of Rock Valley, and Mercury Valley. Densities of tortoises on the NTS are generally low and range from 0 to 45 individuals per square mile, with most habitats probably having densities of 0 to 20 individuals per square mile.

A Biological Assessment on the effects of all NTS activities on desert tortoises, as required by the ESA, was completed in 1991. Reports were prepared on the effects of several projects on NTS desert tortoise populations. These reports included the Biological Assessments for the Nevada Bell fiber optic cable and a housing project in Area 25. The topical report on the known distribution and abundance of desert tortoises on the NTS was also completed.

Other activities associated with the desert tortoise program at the NTS included conducting searches for tortoises at several sites that may be impacted by activities at the NTS, and identifying and searching tortoise relocation sites that may be used for mitigation of activities

at the NTS. In addition, a notice was included in all REECo paycheck envelopes on the subject of the Mojave desert tortoise.

3.12 DOE/NV AUDITS

DOE/NV contractors are routinely audited to identify potential environmental compliance problems. A DOE/HQ inspection of the NTS was conducted in 1987, and a DOE/NV audit was made of the LVAO facilities at both North Las Vegas locations in 1990.

3.12.1 NTS ENVIRONMENTAL SURVEYS

Because several Environmental Survey Action Plan items were also being tracked in the Quarterly Compliance Action Report (used to track "Tiger Team" finding items, see Section 3.13, below), the Environmental Survey Action Plan is considered to be closed as of November 1990. The remaining Environmental Survey Action Plan items are primarily long-term projects assigned to the DOE/NV Environmental Restoration Branch and will be addressed as funding is available.

3.12.2 NON-NTS EG&G/EM AUDITS

The DOE/NV Quality Assurance Division audited the EG&G LVAO facilities in 1990 and made 29 findings. Twenty-six of these have been addressed, and are ready for formal closure. Three findings continue to remain outstanding until corrective actions have been fully implemented.

The DOE Office of Environmental Audit, conducted an environmental audit of EG&G/EM Santa Barbara Operations, Special Technologies Laboratory, and Las Vegas Area Operations including the Remote Sensing Laboratory and the North Las Vegas Facility. There were 22 findings and 4 noteworthy practices. The findings were not considered to be indicative of significant programmatic failings. Eleven findings are currently ready for formal closure. Corrective actions for the remaining 11 findings have not yet been fully implemented.

EPA and State of Nevada officials conducted a hazardous waste management audit on August 7, 1991 of the EG&G/EM, operated, DOE owned, North Las Vegas Facility. The auditors complimented EG&G/EM on their waste management practices and issued no citations nor reported any findings.

3.13 TIGER TEAM COMPLIANCE ASSESSMENT

The DOE Tiger Team Compliance Assessment of the NTS conducted from October 30 to December 1, 1989, was part of a 10-point initiative by the Secretary of Energy to conduct independent oversight compliance and management assessments of environmental, safety, and health programs at over 100 DOE operating facilities.

The Tiger Team identified 149 deficiencies including 45 environmental "findings" in its assessment of the NTS, none of which reflected situations which presented an immediate risk to public health or the environment. Potential noncompliance findings included 35 irregularities with federal or state of Nevada environmental regulations and/or DOE Orders. Ten findings represented conditions which were judged not to meet "best management

practices," i.e., practices which could be improved through application of available or improved methods.

In response to the Tiger Team report, the DOE/NV developed an action plan to address each of the findings. In many cases the planned actions were straightforward and could be readily implemented. Others required or will require substantial funding and years to implement. A schedule for accomplishing all actions was established in 1990, and, assuming funding is made available, all work is planned to be completed by September 30, 1996.

The "most significant findings" identified by the environmental sub-team of the Tiger Team included:

- Incomplete waste characterization for wastes slated for onsite and offsite disposal
- Radioactive wastes being accepted at the Area 3 and Area 5 radioactive waste disposal sites from generators not approved in accordance with DOE/NV procedures
- Various wastes generated on the NTS were managed with insufficient knowledge of hazardous waste-related components in the waste streams

Work continues on responding to these issues. As of April 1, 1992, 80 of the 149 findings have been closed in accordance with the DOE/NV Procedure for Closure of Nevada Operations Office (NV) Action Plan, Revision No. 0, July 13, 1990.

3.14 RADIATION PROTECTION

3.14.1 NTS OPERATIONS

Results of environmental monitoring on the NTS during 1991 showed full compliance with the radiation exposure guidelines of DOE Order 5480.11, "Radiation Protection for Occupational Workers," DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and the 40 CFR 141 National Primary Drinking Water Regulations. Onsite air monitoring results showed average annual concentrations ranging from 8×10^{-4} percent of the DOE Order 5400.5 guidelines for ^{85}Kr to 0.08 percent of the guidelines for $^{239+240}Pu$ in air. Drinking water supplies on the NTS contained 8×10^{-4} percent of the DOE Order 5400.5 guideline and 0.02 percent of the National Primary Drinking Water Regulation for tritium. Supply wells contained 0.002 percent of the DOE Order 5400.5 guideline for $^{239+240}Pu$. Comparisons were made to the guidelines for public consumption although the general public does not consume water from these supplies. The guideline concentrations in DOE Order 5480.11 for occupational workers are one hundred to one thousand times higher than those for the public.

3.14.2 NON-NTS EG&G/EM OPERATIONS

There were no radioactive air emissions, no radioactive or nonradioactive surface water/liquid discharges, subsurface discharges through leaching, leaking, seepage into the soil column, well disposal, or burial at any of the EG&G/EM operations. Use of radioactive materials was primarily limited to sealed sources. However, facilities which use radioactive materials or

radiation producing equipment, with the potential to expose the general population outside the property line to dire radiation within 10% of the exposure standard for the public (100 mrem/yr, DOE Orde 5400.5)) are: SBO during operation of the LINAC; STL, during the operation of the neutron generator; and the LVAO, NLVF High Intensity Source Range. Sealed sources are tested periodically to assure there is no leakage of radioactive material. Documentation of this assessment can be found in the EG&G/EM Radiation Protection Records.

The 1991 fence line radiation monitoring data from the subject facilities revealed a potential public dose of less than 20% of the 100 mrem/year standard.

3.15 OCCURRENCE REPORTING

Occurrences are environmental, health, and/or safety-related events which are reported in several categories in accordance with the requirements of DOE Order 5000.3A, "Unusual Occurrence Reporting System." A listing of the reportable occurrences for off-NTS support facilities and on-NTS locations appears in Tables 3.5 and 3.6.

Table 3.5 Off-Normal Occurrences at Off-NTS Support Facilities

Date	Report No.	Description	Status
01/31/91	NVOO-EGGO-NLVO -1991-0009	EG&G/EM N. Las Vegas, 73 ft^3 soil contaminated with 6 lb. lead	Cleanup & Disposed 4/91
02/08/91	To be prepared	88 containers shipped from TTR, 87 rec'd by disposal facility	Investigating
03/25/91	NVOO-EGGO-RSLO -1991-0016	400 gal. gasoline and 100 gal. diesel spilled at EG&G facility on Nellis AFB	Old fill ports sealed. New ports labeled
07/18/91	NVOO-EGGO-SBOO -1991-1001	Grab sample of effluent had high zinc though facility doesn't use zinc - Santa Barbara, California	Investigation continuing
10/07/91	NVOO-EGGO-AVOO -1991-1002	Release of 30 gal. photo chemicals from storage drum, Amador Valley, California	Catch basin contained spill; Chemicals transferred to polystyrene drums
11/14/91	NVOO-EGGO-KAOO -1991-1004	Radioactive contamination found on forklift, then on another in storage	Vehicles stored pending disposal

Table 3.6 Off-Normal Occurrences at NTS Facilities

Date	Report No.	Description	Status
01/02/91	NVOO-REEC-OMDO 1991-1002	10 - 50 gal. oil spilled, Area 6, Building 6-800	Soil excavated, disposed in sanitary landfill
01/24/91	NVOO-REEC-OMDO 1991-0005	32 gal. oil spilled on pavement and soil, Area 12, P Tunnel Yard	Absorb from pavement, excavate soil, landfilled
01/25/91	NVOO-REEC-OMDO 1991-0011	80 ft^3 soil contaminated with hydrocarbon spills over many years, Area 12, T tunnel	Sampling for mixed waste planned
01/30/91	NVOO-REEC-OMDO 1991-0009	25 - 40 gal. hydraulic oil in 3 yd^3 soil. Area 12 Batch Plant	Soil excavated, disposed in sanitary landfill
02/12/91	NVOO-REEC-EHDO 1991-0012	Liquid leaking from container shipped from Fernald, Ohio	Container sealed, disposed of at RWMS
04/10/91	NVOO-REEC-SSDO 1991-1001	35 gal. hydraulic fluid spill onto soil, Area 23, Excess Yard	Soil excavated, disposed of in sanitary landfill
04/12/91	NVOO-EGGO-LGFS 1991-1001	Leakage of 300 gal. water with ethylene glycol into soil at LGFSTF in Area 5	Leak stopped, repairs made, spill absorbed
04/15/91	NVOO-REEC-EHDO 1991-1004	Worker contaminated handling drums TRU waste, Area 5, RWMS	Area decontaminated, drum overpacked for storage
05/03/91	NVOO-REEC-OMDO 1991-1001	Soil contamination found while drilling monitoring wells Mercury gas station	Extent unknown. Planning remediation method
05/07/91	NVOO-REEC-OMDO 1991-1002	Spill 30 gal. hydraulic fluid onto soil, Area 6, Equipment Yard	Soil excavated and disposed. Waiting results of additional samples
06/17/91	NVOO-REEC-OMDO 1991-1008	Leak of 50 gal. waste oil from tank, Area 6, Heavy-duty Shop	Awaiting results of soil analysis
06/20/91	NVOO-REEC-EHDO 1991-1008	≈10 ft^3 soil contaminated with petroleum product from leaking drum, Area 25, Building 3113	cleanup actions being determined
06/30/91	NVOO-REEC-DMDO 1991-1007	10 yd^3 soil contaminated over time by motor pool operations	Analysis shows nonhazardous. Into landfill
07/01/91	NVOO-REEC-OMDO 1991-1011	≈40 yd^3 soil contaminated by gasoline during re-fueling, Area 23, Service Station	Soil excavated, disposed in sanitary landfill
07/16/91	NVOO-REEC-EHDO 1991-1010	Soil contamination from hydrocarbon spills over many years, Area 23, Fire Training Area	Work plan to characterize site being developed

Table 3.6 (Off-Normal Occurrences at NTS Facilities, cont.)

Date	Report No.	Description	Status
07/18/91	NVOO-REEC-SSDO 1991-1002	Spilled hydraulic oil from excessed equipment, Area 25, MX Yard	Samples taken. Cleanup planned
07/18/91	NVOO-REEC-OMDO 1991-1017	30 yd^3 contaminated from washing equipment with diesel fuel, Area 6, LANL Construction Facility	Samples taken Cleanup initiated
07/24/91	Not Assigned	Pavement subject to oil leaks from generators over many years, Area 18, Pahute Mesa airstrip	Corrective actions under investigation
07/24/91	NVOO-REEC-OMDO 1991-1011	Samples from water haulage trucks exceed coliform standards	Hauling stopped. Corrective actions started
07/30/91	NVOO-REEC-EHDO 1991-1011	Monitoring for closure of hazardous waste trench found medical waste trench, Area 23	Stop work order. Searching for all wastes
07/31/91	NVOO-EGGO-NTSO 1991-1002	Soil contaminated from discharging spent photo chemicals and waste water, Area 20, Trailer 992	Very low levels of contamination. No Action
08/02/91	NVOO-REEC-OMDO 1991-1023	Soil contamination from leak in UST, Area 12 Service Station	Investigating extent of contamination
08/21/91	NVOO-REEC-EHDO 1991-1016	Waste packages received with no stream ID No. Area 5, RWMS	Shipper notified. Procedure modified
09/09/91	NVOO-REEC-EHDO 1991-1019	Stopped disposal of septage in Areas 12 and 23 sewage lagoons, may modify bacterial action	Research on septage effect under study
09/10/91	NVOO-REEC-OMDO 1991-1027	10-15 gal. oil spilled from portable storage tank, Area 6	Spill absorbed, cleanup will be done
09/17/91	NVOO-EGGO-NTSO 1991-1003	Soil contaminated by fuel spill from vehicle	Release reportable. Cleaned up
09/18/91	NVOO-REEC-OMDO 1991-1028	Oil spilled while pumping into tanker with open valve, Area 6 Compound	Spill absorbed, cleanup will be done
10/07/91	NVOO-REEC-EHDO 1991-1022	Cleanup debris dumped on contaminated muck pile, G tunnel, Area 12	Pile fenced & posted. Workers bioassayed
10/10/91	NVOO-REEC-OMDO 1991-1033	Release of oil from Cardwell 500 drill rig, Area 12	Samples collected, spill cleaned up
10/11/91	NVOO-REEC-OMDO 1991-1032	20 gal. oil released from Ideco drill rig at U19bk, Area 19	Drip plan installed, temp catch basin used

Table 3.6 (Off-Normal Occurrences at NTS Facilities, cont.)

Date	Report No.	Description	Status
10/23/91	NVOO-REEC-OMDO 1991-1036	30 to 40 gal. diesel fuel spilled from motor grader, Area 2	Faulty valve replaced, soil sampled.
10/29/91	NVOO-REEC-OMDO 1991-1038	20 gal. oil spilled on ground from forklift, Area 2	Hose connection corrected, soil sampled
10/31/91	NVOO-REEC-OMDO 1991-1040	10 gal. fuel leaked from pressurized fuel line to boiler, Area 6	Spill dammed, soil sampled
11/05/91	NVOO-REEC-EHDO 1991-1025	Sewage backed up into old sewage lagoon Area 6	Blockage removed from new system, old system capped
11/21/91	NVOO-REEC-OMDO 1991-1042	Hydraulic oil released from Ringer Crane, Area 4	Hydraulic line replaced, isolation vibrators being designed
11/21/91	NVOO-REEC-YMPO 1991-1001	25 to 30 gal. diesel spilled from open valve on fuel tank, Area 25	Valve wired shut, outlet plugged
11/25/91	NVOO-REEC-SSDO 1991-1003	15 gal. turbine oil spilled, shut-off valve in "on" position on start-up, Area 6	Automatic trigger removed from nozzle
12/04/91	NVOO-REEC-OMDO 1991-1043	10 to 15 gal. hydraulic oil spilled from overfill of hydraulic tank by auxiliary pump, Area 6	Pump disconnected
12/05/91	NVOO-REEC-EHDO 1991-1026	Radioactive contamination found at abandoned test site, Area 25	Levels too low for fencing, area posted
01/10/92	NVOO-REEC-ADMN 1992-0003	Waste oil release at LANL construction site, Area 6	Samples collected for analysis
01/17/92	NVOO-REEC-OMDO 1992-0002	73 gal hydraulic oil spill, Op. Equipment Yard, Area 6	Samples collected for analysis
01/23/92	NVOO-REEC-OMDO 1992-0003	Motor oil release from sight glass U-2gj, Area 2	Sample results indicate more excavation needed
02/13/92	NVOO-REEC-OMDO 1992-0005	Spill of oil and Pb at Pull Test Facility, Area 2	Prelim. results TPH >100 ppm, Pb >5 ppm
02/12/92	NVOO-REEC-OMDO 1992-0006	Soil contaminated with oil over many years, UE-12n#14, UE-12p#06 UE-12t#08, UE-12t#06 an N pad	These are abandoned drill sites. All have TPH levels > 100 ppm
02/13/92	NVOO-REEC-OMDO 1992-0007	Drinking water sample positive for coliforms, Area 3 Canteen	Resample of water showed no coliforms
02/18/92	NVOO-REEC-OMDO 1992-0009	Hydraulic oil release, Fuel and Lube Yard, Area 6	Soil excavated and placed in drums for disposal
02/24/92	NVOO-REEC-ADMN 1992-0005	50 - 100 gal. diesel fuel spill Mud Plant, Area 3	Excavation ongoing, samples being analyzed

Table 3.6 (Off-Normal Occurrences at NTS Facilities, cont.)

Date	Report No.	Description	Status
02/25/92	NVOO-REEC-OMDO 1992-0014	80 gal. hydraulic oil spilled, Op. Equipment Yard, Area 6	Sampling underway.
03/24/92	NVOO-REEC-OMDO 1992-0018	Oil spill covering 280 ft^2, Crane Yard, Area 2	Sampling being planned
03/24/92	NVOO-REEC-OMDO 1992-0019	Diesel fuel spill, N Tunnel Road Area 12	Sampling being planned
03/30/92	NVOO-REEC-OMDO 1992-0021	20 gal. of hydraulic fluid spilled on concrete apron, Area 12	Cleaned up with absorbent placed in drum for disposal

Other Off Normal Occurrences - 1991

1/8/91 A REECo employee driving a service truck, backed into a pallet containing four, 55 gallon drums containing a water/methanol mixture which were located at the EG&G/EM, Desert Rock Airstrip on NTS. One partially full barrel fell over and fluid escaped after the rotted plastic bung crumbled. Site remediation of spilled material was deemed unnecessary.

1/09/91 A partially opened valve was left unattended causing the solution in the pyrophosphate copper tank located in the EG&G/EM, North Las Vegas Facility, B-1 building, to overflow. This resulted in a 2 gallon release of the tank solution onto the floor. The liquid was contained and immediately cleaned up.

1/25/91 Two gallons of 1,1,1-trichloroethane were spilled onto the asphalt in the B-4 yard area, at the EG&G/EM, Las Vegas Area Operations, North Las Vegas Facility. The spill occurred while an employee was transferring the liquid from one container to another. The spilled liquid was immediately contained and cleaned up.

1/30/91 Two 500 ml samples of JP-4 fuel and two, 500 ml samples of hydraulic oil were improperly transferred by a hazardous waste contractor from the EG&G/EM, Las Vegas Area Operations, Remote Sensing Laboratory to the EG&G/EM, North Las Vegas Facility.

4/23/91 Three hundred gallons of an ethylene glycol and water mixture for a fire suppression system at the EG&G/EM operated LGFS on the NTS, leaked onto the ground from a level alarm switch. The switch had been replaced the day before by REECo maintenance personnel. Upon discovery, the leak was immediately stopped. The liquid on the soil was absorbed, containerized and managed as solid waste. No further action was taken based on a soil contamination survey that was conducted.

6/24/91 During an inspection of the EG&G/EM operated Trailer 992 it was discovered that photographic chemicals and wastewater were being discharged onto the ground underneath the trailer. The discharge was immediately discontinued. No further action was taken based on a soil contamination survey that was conducted.

8/27/91 An EG&G/EM operated fuel truck was filled to capacity and parked on a slight incline at CP-150 on the NTS. There was not enough outage to allow for fuel expansion from the heat. Fuel was released through the vent overflow located at the top of the tank.

8/30/91 A one gallon bottle containing a mixture of methanol, ethanol, ethylene glycol, dimethyl sulfoxide, and pseudocumene leaked onto the EG&G/EM, North Las Vegas Facility, hazardous waste accumulation pad. The spill was contained and immediately cleaned up.

3.16 PERMIT SUMMARY

For facilities used in the operation and maintenance of the NTS and non-NTS facilities, the DOE/NV contractors providing such operation and support activities for the DOE/NV have been granted numerous permits by the appropriate regulatory authorities. In addition to the existing number of permits in 1991 (shown in Table 3.7), five RCRA permits were in various stages of the approval process at the end of 1991.

3.17 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT

There were no projects in 1991 which required consultation for floodplain management. NTS design criteria does not specifically address floodplain management, however, all projects are reviewed for areas which would be affected by a 100 year flood pursuant to DOE Order 6430.1A.

3.18 EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS

There were no projects in 1991 which required consultation for protection of wetlands. NTS design criteria does not specifically address protection of wetlands, however, all projects are reviewed pursuant to the requirements of DOE Order 5400.1.

Table 3.7 Environmental Permit Summary - 1991

	Air Pollution	Wastewater	Drinking Water	Number of EPA Generator User IDs [a]	County Hazardous Waste Generator	Endangered Species Act	Storage of Flammables (City)
NTS	38	4	6	2		1	
Las Vegas Area Operations Office	28[b]	2		1			
Amador Valley Operations		1		1			
Kirtland Operations		1		2			
Los Alamos Operations				1			
Santa Barbara Operations		2[b]		2			
Special Technologies Laboratory (Santa Barbara)	1	1[b]		1			
Woburn Cathode Ray Tube Operations	1	1		1			1[b]
Washington Aerial Measurements Dept.							
TOTAL	68	12	6	11		1	1

(a) Biennial report required.
(b) Routine monitoring of emissions is not required.

4.0 ENVIRONMENTAL PROGRAM INFORMATION

The environmental monitoring and compliance program for the NTS and offsite EG&G Energy Measurements, Inc. (EG&G/EM), facilities consists of (1) radiological monitoring, (2) nonradiological monitoring, and (3) environmental permits and operations compliance.

4.1 RADIOLOGICAL MONITORING

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There are two radiological monitoring programs associated with the NTS, one onsite and the other offsite. The onsite program is conducted by several organizations. Reynolds Electrical & Engineering Co., Inc. (REECo), the operating contractor at the NTS, is responsible for environmental surveillance and effluent monitoring. Several other organizations, such as the Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Desert Research Institute (DRI), the U. S. Environmental Protection Agency (EPA), and participants in the Basic Environmental Compliance and Monitoring Program (BECAMP) also make radiological measurements. The offsite program is conducted by the EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV).

4.1.1 ONSITE MONITORING

At the NTS radiological effluents may originate from (1) tunnels, (2) underground test event sites (at or near surface ground zeros [SGZs]), and (3) facilities where materials are either used, processed, stored, or discharged. All of these types of sites have the potential or are known to discharge radioactive effluents into the environment.

Air sampling was conducted for radioactive particulates, halogens, noble gases, and tritiated water vapor (see Figure 4.1 for sampling locations). Ambient gamma radiation monitoring was conducted throughout the Site (see Figure 4.2). Potable water from groundwater wells, spring water, well reservoirs, and waste disposal ponds were sampled for radiological substances (see Figures 4.3 and 4.4). These tasks made up the environmental surveillance program on the NTS. Table 4.1 is a summary of all routine environmental surveillance.

4.1.1.1 CRITERIA

DOE Order 5400.1, "General Environmental Protection Program," published in November of 1988, established the onsite environmental protection program requirements, authorities, and responsibilities for DOE operations. These mandates required compliance with applicable federal, state, and local environmental protection regulations. Other orders applicable to

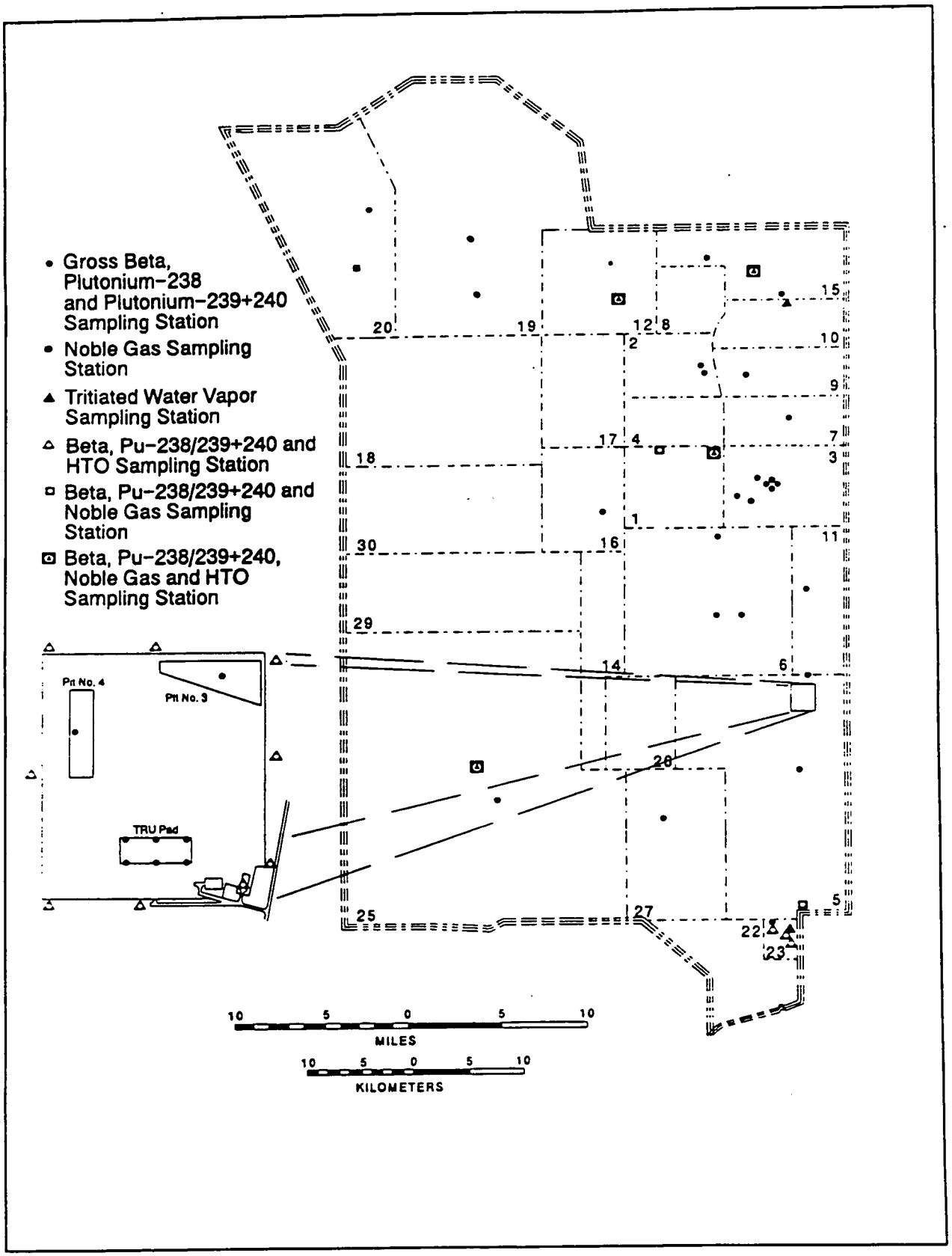

Figure 4.1 Air Sampling Stations on the NTS - 1991

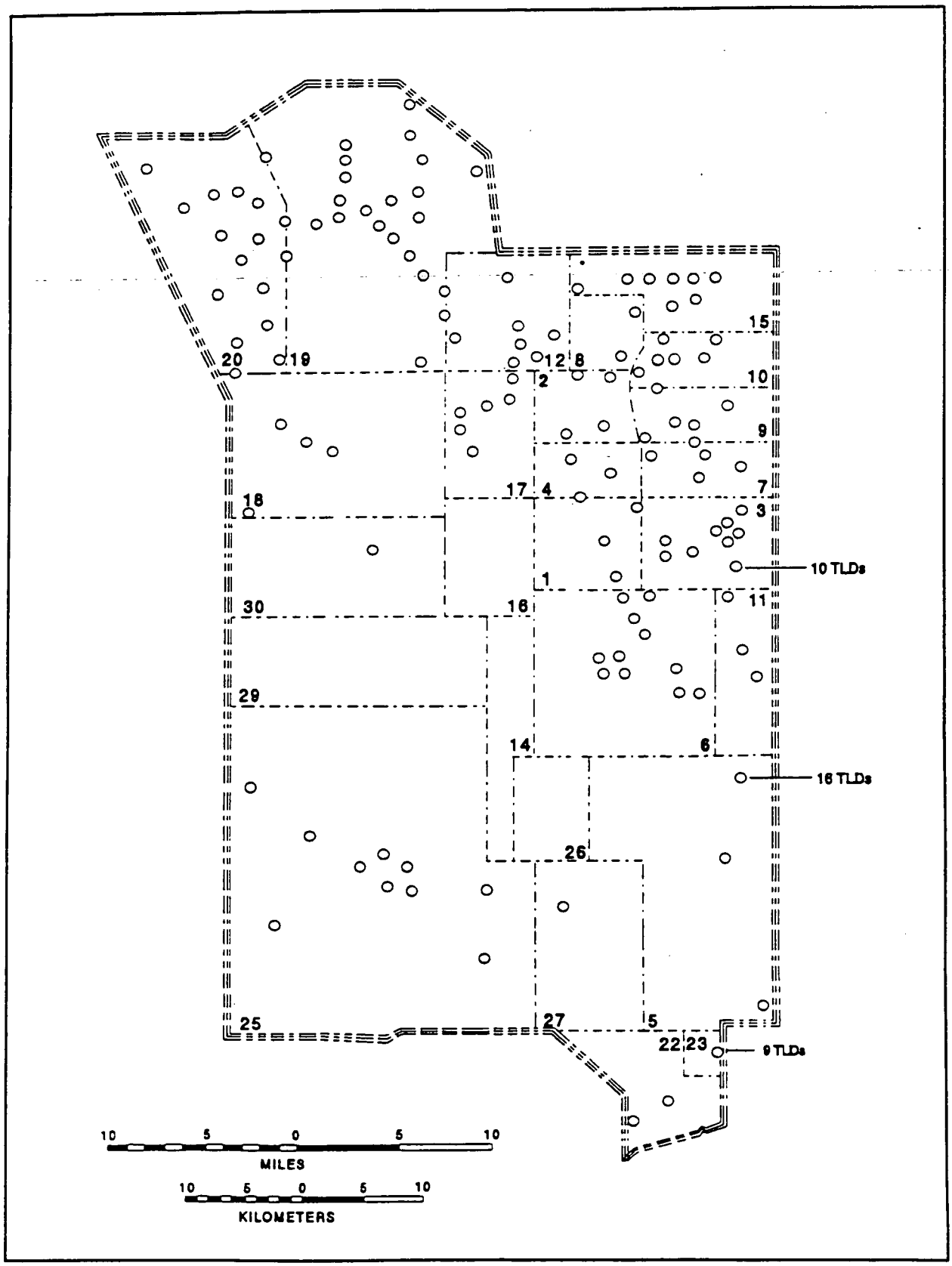

Figure 4.2 Thermoluminescent Dosimeter Stations on the NTS - 1991

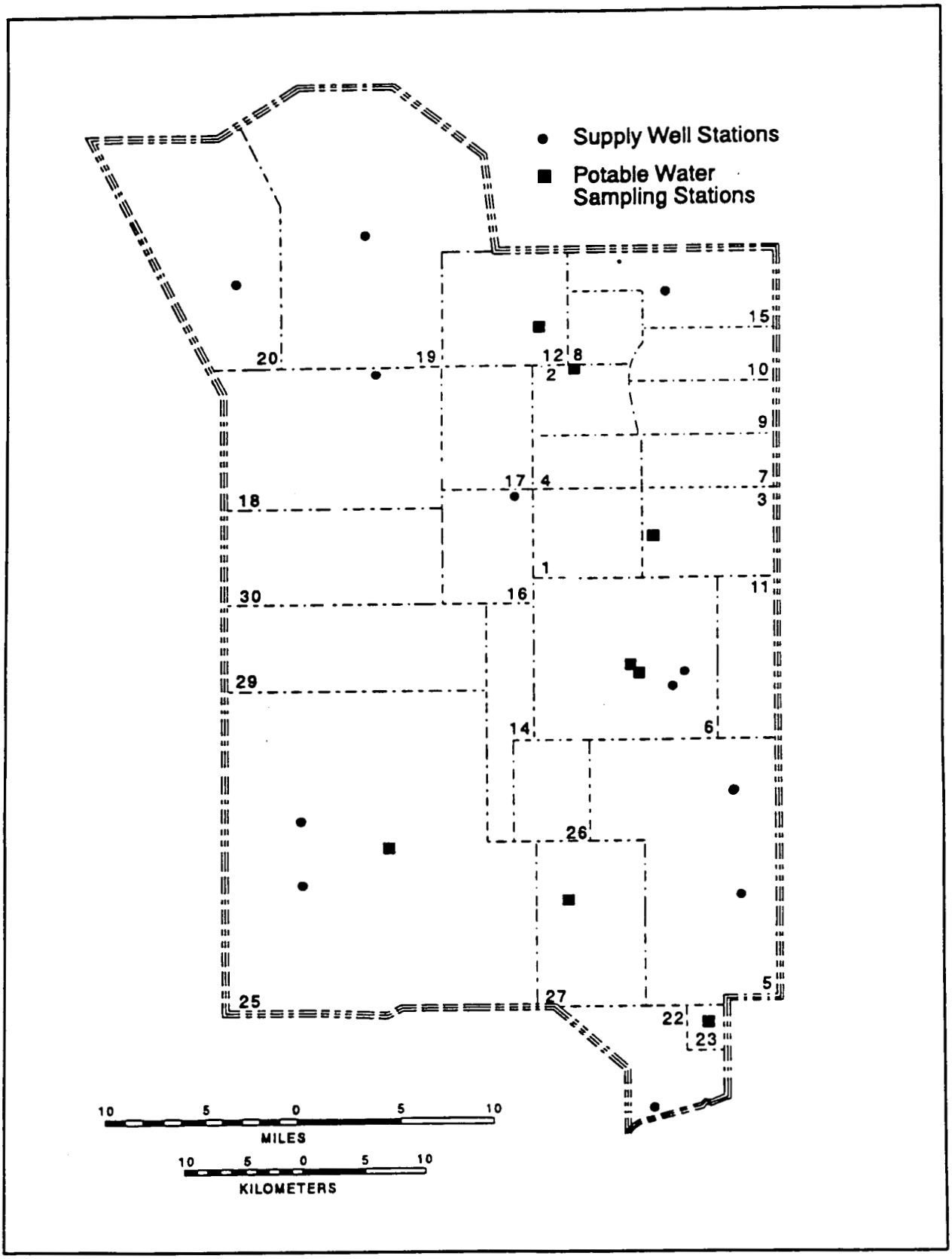

Figure 4.3 Supply Well and Potable Water Sampling Stations on the NTS - 1991

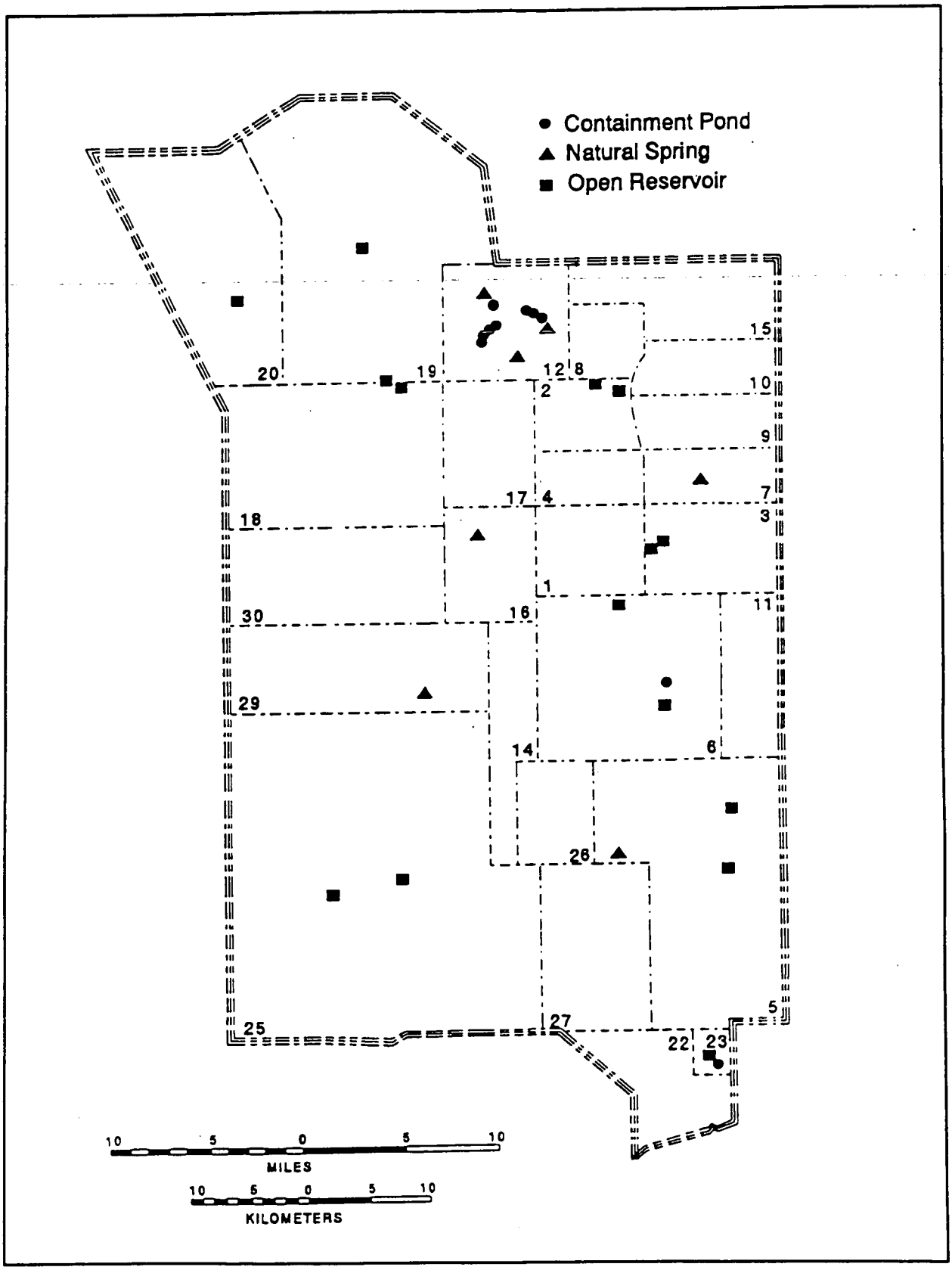

Figure 4.4 Surface Water Sampling Locations on the NTS - 1991

Table 4.1 *Summary of Onsite Environmental Sampling Program - 1991*

Sample Type	Description	Collection Frequency	Number of Sampling Locations[a]	Type of Analysis
Air	Sampling through Whatman GF/A glass fiber filter and a charcoal cartridge	Weekly	52	Gamma spectroscopy, gross β, ($^{238,239+240}$Pu, monthly composite)
	Low-volume sampling through silica gel	Biweekly	17	HTO (tritium oxide)
	Low-volume sampling	Weekly	7	^{85}Kr and ^{133}Xe
Potable Water	Grab sample	Weekly	9	Gamma spectroscopy, gross β, ^{3}H, ($^{238,239+240}$Pu, gross α quarterly), (^{90}Sr annually)
Potable Supply Wells	Grab sample	Monthly	10	Gamma spectroscopy, gross β, ^{3}H, ($^{238,239+240}$Pu,) ^{226}Ra, ^{3}H enrichment, gross α, quarterly), (^{90}Sr annually)
Non-Potable Supply Wells	Grab sample	Monthly	13	Gamma spectroscopy, gross β, ^{3}H, ($^{238,239+240}$Pu, gross α, quarterly), (^{90}Sr annually)
Open Reservoirs	Grab sample	Monthly	15	Gamma spectroscopy, gross β, ^{3}H, ($^{238,239+240}$Pu quarterly), (^{90}Sr annually)
Natural Springs	Grab sample	Monthly	7	Gamma spectroscopy, gross β, ^{3}H, ($^{238,239+240}$Pu quarterly), (^{90}Sr annually)

Table 4.1 (Summary of Onsite Environmental Sampling Program - 1991, cont.)

Sample Type	Description	Collection Frequency	Number of Sampling Locations[a]	Type of Analysis
Containment Ponds	Grab sample	Monthly	9	Gamma spectroscopy, gross β, ^{3}H, ($^{238,239+240}Pu$ quarterly), (^{90}Sr annually)
Sewage Lagoons	Grab sample	Quarterly	3	Gamma spectroscopy, gross β, ^{3}H, ($^{238,239+240}Pu$ quarterly), (^{90}Sr annually)
External Gamma Radiation Levels	UD-814AS thermoluminescent dosimeters	Quarterly	187	Total quarterly exposure

(a) Not all of these locations were sampled because of inaccessibility or lack of water.

environmental monitoring include DOE Order 5480.11, "Radiation Protection for Occupational Workers"; DOE Order 5480.1B, "Environment, Safety, and Health Program for Department of Energy Operations"; DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements"; DOE Order 5400.5, "Radiation Protection of the Public and the Environment"; and DOE/EH-0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.

4.1.1.2 EFFLUENT MONITORING

Effluent monitoring efforts at the NTS focused on monitoring nuclear test event sites, tunnel discharge waters, and the Area 6 radiological Decontamination Facility. During 1991 effluent monitoring was conducted at four of the eight test event sites, four tunnel facilities, one decontamination facility, and one groundwater radionuclide migration research water well.

LIQUID EFFLUENT MONITORING

Radiologically contaminated water was discharged from N, T, and E Tunnels in the Rainier Mesa (Area 12) range. A grab sample was collected monthly from each tunnel's effluent discharge point and from each tunnel's contaminated water holding pond. These samples were analyzed for tritium (^{3}H), gross beta, and gamma emitters. In addition, quarterly samples were analyzed for ^{238}Pu and $^{239+240}Pu$, and an annual sample was analyzed for ^{90}Sr. Tritium was the radionuclide most consistently detected at the tunnel sites. Other radionuclides were detected infrequently.

A conservative estimate of the flow rate from each tunnel was made during the first quarter of 1991, but beginning in April, the liquid effluents from the tunnel were measured by equipment installed by the Desert Research Institute. These methods were used to quantify the total annual radiological effluent release. The average annual concentration (in curies/gallon) of the radionuclide of interest in the effluent liquid was multiplied by the total quantity of liquid discharged from the tunnel during a calendar year. This value was calculated for each tunnel and summed to obtain the total liquid radiological effluent discharged from the facility.

The flow to the Area 6 Decontamination Facility holding pond was also estimated, using the number of gallons measured to clean a truck and multiplying by the number of trucks cleaned per year. Then the total quantity of water discharged was multiplied by the concentration of ^{3}H in the water. During 1991 there were no radionuclides other than ^{3}H detected in the pond influent.

At the radionuclide migration research well in Area 5, the flow of water was intentionally discharged to a collecting pond. This flow was maintained with a pump at 600 gallons per minute. The well water was contaminated with measurable amounts of ^{3}H. Therefore, the total discharge of ^{3}H to the environment was determined fairly accurately. After collection of the August sample, this research project was terminated.

Typical lower limits of detection for water analyses were:

- Gross α: 1×10^{-12} µCi/mL
- Gross ß: 8×10^{-10} µCi/mL
- Gamma Spectroscopy: 2×10^{-7} µCi/mL
- Tritium (conventional): 5×10^{-7} µCi/mL
- Tritium (enrichment): 2×10^{-8} µCi/mL)
- ^{90}Sr: 9×10^{-10} µCi/mL
- ^{226}Ra: 2×10^{-9} µCi/mL
- ^{238}Pu: 1×10^{-8} µCi/mL
- $^{239+240}Pu$: 4×10^{-11} µCi/Ml

AIRBORNE EFFLUENT MONITORING

Pahute Mesa events in Area 19 and 20 were monitored for ^{85}Kr and ^{133}Xe. For each event conducted in these areas during 1991, up to three portable noble gas samplers were placed in the vicinity of the SGZ. Portable noble gas samplers were used to detect any seeps of noble gases created from the fission process. The portable noble gas sampling unit used was similar in design to the permanent sampler used for environmental surveillance. The sampling system is described in "Environmental Surveillance" below.

To comply with the requirements of 40CFR61, "National Emission Standards for Air Pollutants: Radionuclides" and DOE/EH-0173T Regulatory Guide, an isokinetic sampling system was

installed in the P tunnel ventilation pipe in September 1991 to obtain confirmatory measurements. The system collects cumulative samples of airborne particulates, radioiodine, noble gases, and tritiated water vapor. The samples are collected and analyzed biweekly for tritium and weekly for all other radionuclides. The system is still under test.

4.1.1.3 ENVIRONMENTAL SURVEILLANCE

Environmental surveillance was conducted onsite throughout the NTS. Equipment at several fixed, continuously sampling stations was used to monitor for radioactive materials in the air, surface water, and groundwater.

AIR MONITORING

The environmental surveillance program maintained samplers designed to detect airborne radioactive particles, radioactive gases (including halogens and noble gases), and radioactive hydrogen (^{3}H) as water vapor in the form $^{3}H^{3}HO$ or ^{3}HHO.

Air sampling units were located at 52 stations on the NTS to measure radionuclides in the form of particulates and halogens. All placements were chosen primarily to provide monitoring of radioactivity at sites with high worker population density. Geographical coverage, access, and availability of commercial power were also considered in site selection.

An air sampling unit consisted of a positive displacement pump drawing air through a nine-centimeter diameter Whatman GF/A glass fiber filter for trapping particulates, followed by a charcoal cartridge collecting radioiodines. The filter and cartridge were mounted in a plastic, cone-shaped sample holder. The unit drew approximately 140 L/min of air. A dry-gas meter measured the volume of air displaced over the sampling period (typically seven days). The unit collected approximately 1400 cubic meters of air during the sampling period.

The filters were held for no less than five nor more than seven days prior to analysis to allow naturally occurring radon and its daughter products to decay. Gross beta counting was performed with a gas-flow proportional counter for 20 minutes. The lower limit of detection for gross beta, assuming typical counting parameters, was 2×10^{-16} µCi/Ml using a ^{90}Sr calibration source. Gamma spectroscopy of the filter and cartridge was accomplished using germanium detectors with an input to a 2000-channel spectrometer, calibrated at 1 kiloelectronvolt (keV) per channel from 0.02 to 2 megaelectronvolts (MeV) using a NIST traceable mixed radionuclide source.

Weekly air samples for a given sampling station were prepared in batches on a monthly basis and radiochemically analyzed for ^{238}Pu and $^{239+240}Pu$. This procedure incorporated an acid dissolution and an ion-exchange recovery on a resin bed. Plutonium was deposited by plating on a stainless steel disk. The chemical yield of the plutonium was determined with an internal ^{236}Pu tracer. Alpha spectroscopy was performed utilizing a solid-state silicon surface barrier detector. The lower limit of detection for ^{238}Pu and $^{239+240}Pu$ was approximately 1×10^{-17} µCi/mL.

The radioactive noble gases ^{85}Kr and ^{133}Xe were determined in continuous samples of air taken at seven permanent locations. The noble gas samplers maintained a steady sampling flow rate for one week. Noble gas sampling units were housed in a metal tool box and, with the exception of a few minor differences, were identical to the portable units used to monitor effluents. Three metal air bottles were attached to the sampling units with short hoses. A

vacuum was maintained on the first bottle by pumping the sample into the other two bottles. The flow rate was approximately 80 mL/min. The two collection bottles were exchanged weekly and yielded a sample volume of about 400 liters each at standard conditions.

The noble gases were separated from the atmospheric sample by cryogenic gas fractionation. Water and carbon dioxide were removed at room temperature, and the krypton and xenon were collected on charcoal at liquid nitrogen temperatures. These gases were transferred to a molecular sieve where they were separated from any remaining gases and each other. The krypton and xenon were transferred to separate scintillation vials and counted on a liquid scintillation counter. The lower limits of detection for ^{85}Kr and ^{133}Xe were 4×10^{-12} and 10×10^{-12} µCi/mL, respectively.

Airborne tritiated water vapor was monitored at 17 permanent locations throughout the NTS. Constant air flow over moisture-collecting material was maintained for a two-week period, during which airborne moisture was extracted and, at the end of the sampling period, transferred to the onsite laboratory for analysis. The airborne ^{3}H sampler was capable of unattended operation for up to two weeks in desert areas. A small electronic pump drew air into the apparatus at approximately 0.6 L/min, and the tritiated water vapor was removed from the air stream by two silica-gel drying columns. Appropriate aliquots of condensed moisture were obtained by heating the silica gel. Liquid scintillation counting determined the tritiated water vapor activity. The lower limit of detection for tritiated water vapor analysis was 3×10^{-13} µCi/mL of air.

AMBIENT GAMMA MONITORING

Ambient gamma monitoring was conducted at 187 stations within the NTS through use of thermoluminescent dosimeters (TLDs). A TLD emits light when it is heated after having been exposed to radiation, hence the term "thermoluminescent." The total amount of light given off by the crystal is proportional to the amount of energy absorbed from the radiation; therefore, the intensity of light emitted from the TLD crystal is directly proportional to the radiation exposure.

The dosimeter used was the UD-814AS environmental dosimeter manufactured by Panasonic. One It consists of four elements housed in an air-tight, water-tight, ultraviolet-light-protected case. The first element, made of lithium borate, was only slightly shielded in order to capture low-energy radiation. The other three elements, made of calcium sulfate, were shielded by 1000 mg/cm^2 of plastic and lead to monitor penetrating gamma radiation only. TLDs were deployed for a period of one calendar quarter. Each TLD in its holder was placed about one meter above the ground at each monitoring location.

WATER MONITORING

Water samples were collected at various frequencies from selected potable water consumption points, supply wells, natural springs, open reservoirs, sewage lagoons, and containment ponds. The frequency of collection was determined on the basis of a preliminary radiological pathways analysis. Potable water was collected weekly; supply wells, springs, reservoirs, and containment ponds were sampled monthly; and sewage lagoons were sampled quarterly. Samples were collected in one-liter glass containers. All samples were analyzed for gross beta, tritium, and gamma-emitting radionuclides. Plutonium analyses were performed on a quarterly basis and strontium analyses annually. Samples of potable water

were also analyzed for gross alpha, for tritium by enrichment, and for ^{226}Ra on a quarterly basis.

A 500-mL aliquot was taken from the water sample and counted in a Nalgene bottle for gamma activity with a germanium detector. A 5-mL aliquot was used for ^{3}H analysis by liquid scintillation counting. The remainder of the original sample was evaporated to 15 mL, transferred to a stainless steel counting planchet, and evaporated to dryness after the addition of a wetting agent. Alpha and/or beta analyses were accomplished with a gas-flow proportional counter, counting the samples for 100 minutes.

Tritium enrichment analyses were performed by concentrating the volume and tritium content of a 250 mL sample aliquot to 10 mL by electrolysis and analyzing a 5 mL portion of the concentrate by liquid scintillation counting. The ^{226}Ra concentrations were determined from low-background gamma spectrometry analyses of radium sulfate. The samples were prepared by adding a barium carrier and ^{225}Ra tracer to 800 mL of sample, precipitating the barium and radium as a sulfate, separating the precipitate, and counting for 500 minutes.

For the quarterly and annual analyses of water samples, an additional one liter sample was collected for non-potable water and an additional two liters for potable water. The radiochemical procedure for plutonium was similar to that previously described in this chapter under "Air Monitoring." Alpha spectroscopy was used to measure any ^{238}Pu and $^{239+240}Pu$ present in the sample.

WASTE MANAGEMENT SITE MONITORING

Environmental surveillance was conducted on the NTS at Radioactive Waste Management Project sites. These sites were used for the disposal of radioactive waste materials as low-level waste (LLW) from the NTS and from other DOE facilities. Shallow disposal in trenches, pits, augered shafts, and subsidence craters was accomplished at the Area 5 Radioactive Waste Management Site (RWMS) and at the Area 3 Bulk Waste Management Facility (BWMF).

The Area 5 RWMS contains the LLW disposal unit, the transuranic waste storage cell, and the Greater Confinement Disposal Unit. The Area 3 BWMF accepted bulk LLW which could not be packaged. Much of the waste material buried there was contaminated soil and metal remaining from the atmospheric testing of nuclear weapons at the NTS. The materials were deposited in subsidence craters (craters which resulted from surface ground collapse after underground nuclear detonations, see Chapter 2, Figure 2.5).

Ambient monitoring included 16 permanent air particulate/halogen sampling stations, nine permanent tritiated water vapor sampling stations placed on and around the RWMS in Area 5, and 24 TLD stations.

The BWMF was surrounded by four air particulate/halogen sampling stations with several TLD stations located nearby.

RADIONUCLIDE MIGRATION AND UPTAKE STUDIES

A series of studies on the potential of subsurface radionuclide migration were continued on the NTS by the DRI, USGS, LANL, and LLNL. These studies included:

- Field research on contamination enhancement of groundwater by water drainage through subsidence craters
- Study of precipitation recharge effects on Pahute Mesa groundwater recharge
- Unsaturated zone migration of radionuclides in the vicinity of the CAMBRIC event migration study site ditch (see Section 6.1.2.2). Although the well was closed down at the end of August 1991, observations of the water in the ditch as it evaporated continued through the end of the year.
- Geologic formation fluid pressure studies in Area 3 and Area 4
- Experiments on the role of colloidal transport of radionuclides in groundwater

4.1.1.4 SPECIAL ENVIRONMENTAL STUDIES

The Basic Environmental Compliance and Monitoring Program (BECAMP) was involved in special studies on the NTS that focused on (1) the movement of radionuclides through the environment and (2) the resultant dose to man. BECAMP used the past accomplishments of two former DOE/NV-sponsored programs at the NTS, the Nevada Applied Ecology Group (NAEG) and the Radionuclide Inventory and Distribution Program (RIDP), in ongoing efforts to design effective programs to assess changes over time in the radiological conditions on the NTS, update human dose-assessment models, and provide information to DOE/NV for site restoration projects and compliance with environmental regulations.

The main objective of one group in BECAMP (Task 1 - Movement of Radionuclides On and Around the NTS) has been to determine the rate of movement of surface-deposited radionuclides in four categories: horizontal movement, water-driven erosional transport, vertical migration, and wind-driven resuspension. Efforts in 1991 included (1) conducting a characterization study of resuspension processes from a plutonium-contaminated site, (2) preparing final documentation of field monitoring techniques to detect changes in radionuclide concentrations in soil, and (3) development of a study plan for *in situ* surveys of water-erosion channels through plutonium-contaminated surface soils.

A second task in the BECAMP program (Task 2 - Human Dose Assessment Models) has been to update the NAEG/NTS dose-assessment model. The NAEG/NTS model estimated the dose, via ingestion and inhalation, to man from $^{239+240}Pu$. The BECAMP dose-assessment model is an expanded version of the NAEG model that has been updated to include all significant radionuclides in the NTS environs and all exposure pathways. The results of an analysis of the NAEG model for sensitivity of calculated doses to relative variations in levels of radionuclides in soil and for uncertainty in model parameters were presented in a paper published this year (Kercher and Anspaugh 1991). In addition, work began on the estimation of realistic uncertainties of model input parameters that involved analyzing NTS soil-plutonium concentrations and resuspension data. From this work, a second and related investigation

was conducted to analyze the uncertainties in predicted radionuclide body burdens and doses from discrete and continuous stochastic source terms.

Another group within BECAMP (Task 4 - Annual Peer-Reviewed Publications) has been assigned the task of preparing a major yearly thematic, peer-reviewed publication that addresses an important issue related to the potential environmental impacts of past, present, and future activities at the NTS and its environs. In 1991 a paper dealing with the possible differential movement of plutonium isotopes (^{238}Pu versus $^{239+240}Pu$) in the NTS environment was completed. A report on the findings and conclusions from the RIDP was also completed in 1991 (McArthur 1991).

4.1.2 OFFSITE MONITORING

Under the terms of an Interagency Agreement between DOE and EPA, the EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV) conducts an Offsite Radiation Safety Program in the areas surrounding the NTS. Personnel from EMSL-LV provide support for each nuclear weapons test conducted at the NTS. Another component of EMSL-LV's program is public information and community assistance activities. The third and largest component of EMSL-LV's program is routine monitoring of potential human exposure pathways.

For each nuclear weapons test conducted at the NTS in 1991, EMSL-LV monitoring technicians were stationed in the predicted downwind direction and, for tests of magnitudes expected to cause detectable offsite ground motion, at underground mines in the area. Senior EPA personnel served on the Test Controller's Scientific Advisory Panel. Tests were only conducted when meteorological conditions were such that any release would have been carried towards sparsely populated, controllable areas. Radiation sampling and tracking aircraft operated by EG&G/EM were flown over the NTS immediately following each test to gather meteorological and radiological data. There were no releases in 1991; had a release occurred, the monitoring technicians would have deployed mobile monitoring instruments as directed from the NTS Control Point via two-way radio communications, implemented protective actions, and collected samples for prompt analysis. Information from the radiation sampling and tracking aircraft would have assisted in positioning the EMSL-LV mobile radiation monitoring technicians.

Town hall meetings and public information presentations provide a forum for increasing public awareness of NTS activities, disseminating radiation monitoring results, and addressing concerns of residents related to environmental radiation and possible health effects. Community radiation monitoring stations (CRMSs) have been established in prominent locations in a number of offsite communities. These CRMSs contain samplers for several of the monitoring networks and are managed by a local resident. The University of Utah and Desert Research Institute (DRI) are cooperators with EPA in the CRMS program.

Routine environmental surveillance networks, described in the following subsections, monitor radiation activity in air, atmospheric moisture, milk, local foodstuffs, and groundwater. Ambient gamma radiation levels are continuously monitored at selected locations using Reuter-Stokes pressurized ion chambers (PICs) and thermoluminescent dosimeters (TLDs). Additional atmospheric monitoring includes air samplers, noble gas samplers, and atmospheric moisture (tritium-in-air) samplers. Milk, game and domestic animals, and foodstuffs (fruits and vegetables) are routinely sampled and analyzed. Some residents in the offsite areas participate in TLD and internal dosimetry networks.

Groundwater on and in the vicinity of the NTS is monitored in the Long-Term Hydrological Monitoring Program (LTHMP). Data from these monitoring networks are used to calculate an annual exposure dose to the offsite residents, as described in Chapter 6, "Dose Assessment."

4.1.2.1 AIR MONITORING

The Air Sampling Network (ASN) was designed to monitor the areas within 350 kilometers (220 miles) of the NTS, with some concentration of stations in the prevailing downwind direction. Station location was dependent upon the availability of electrical power and, at stations distant from the NTS, on a resident willing to operate the equipment. This continuously operating network was supplemented by a standby network which covered the contiguous states west of the Mississippi River. The standby samplers were identical to those used at the active stations and were operated by state and municipal health department personnel or by other local residents.

During 1991 the ASN consisted of 33 continuously operating sampling stations (see Figure 4.5 for these locations) and 76 standby stations (Figure 4.6) that were activated one week per quarter. The air sampler at each station was equipped to collect particulate radionuclides on fiber filters and gaseous radioiodines in charcoal cartridges. The filters and charcoal cartridge samples from all active stations and the filters from standby stations received complete analyses by EMSL-LV. The charcoal cartridge samples from standby stations were analyzed only if there was some reason to expect the presence of radioiodines.

Samples of airborne particulates were collected at each active station on 5-cm (2.0-in) diameter, glass-fiber filters at a flow rate of about 80 m^3 (2800 ft^3) per day. Filters were changed after sampler operation periods of one week (approximately 560 m^3 or 20,000 ft^3). Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodine were changed at the same time as the filters.

A second part of the EMSL-LV offsite air network was the Noble Gas and Tritium Surveillance Network (NGTSN). The radionuclides detected were noble gases and tritium emitted from nuclear reactors, reprocessing facilities (non-NTS facilities) and worldwide nuclear testing. The locations of the NGTSN stations are shown in Figure 4.7. The NGTSN was designed to detect any increase in offsite levels due to possible NTS emissions. Network samplers were typically located in populated areas surrounding the NTS and other samplers were located in communities at some distance from the NTS. In 1991 this network consisted of 21 noble gas samplers and 22 tritium-in-air samplers, three on standby, located in the states of Nevada, Utah, and California.

Noble gas samples were collected by compressing air into storage tanks. The equipment continuously sampled air over a seven-day period and stored approximately 0.6 m^3 (21 ft^3) of air in the tanks. The tanks were exchanged weekly and returned to the EMSL-LV Radioanalysis Laboratory for analysis. Analysis started by condensing the samples at liquid nitrogen temperature followed by gas chromatography to separate the gases. The separate fractions of xenon and krypton were dissolved in scintillation cocktails and counted in a liquid scintillation counter.

For ^3H sampling, a molecular sieve column was used to collect water from the air. Up to 10 m^3 (350 ft^3) of air were passed through the column over a seven-day sampling period. Water

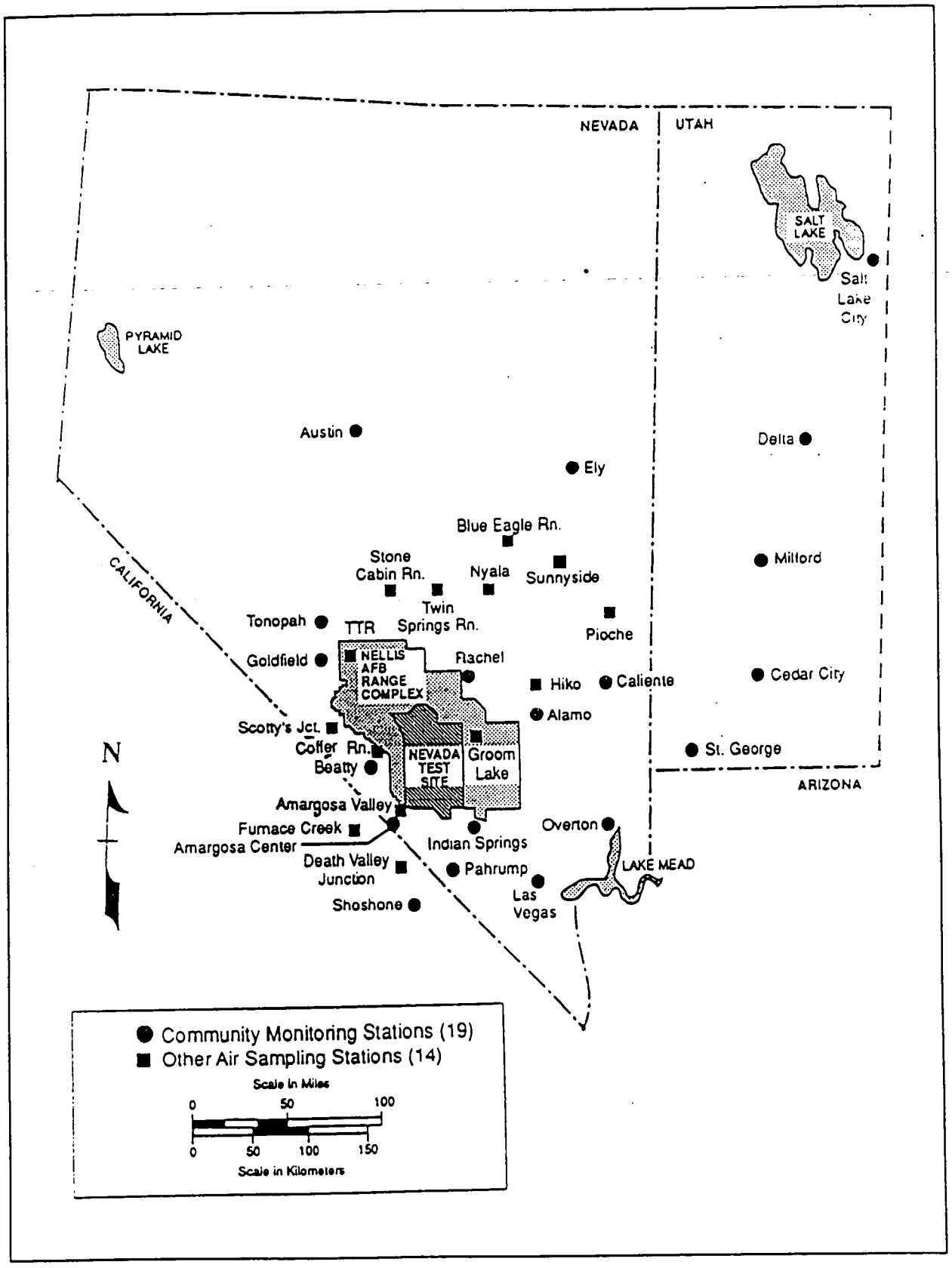

Figure 4.5 Air Surveillance Network Stations - 1991

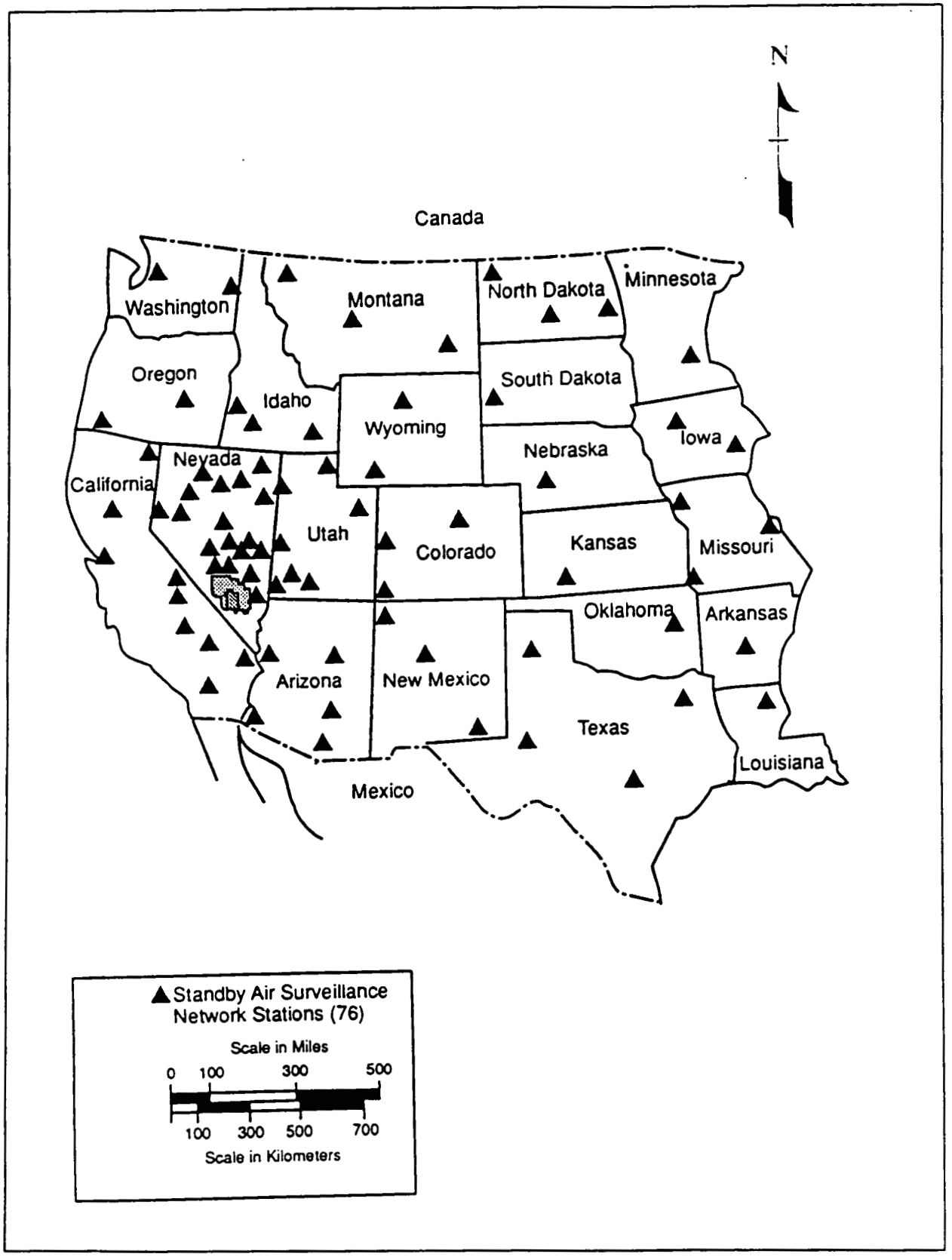

Figure 4.6 Standby Air Surveillance Network Stations - 1991

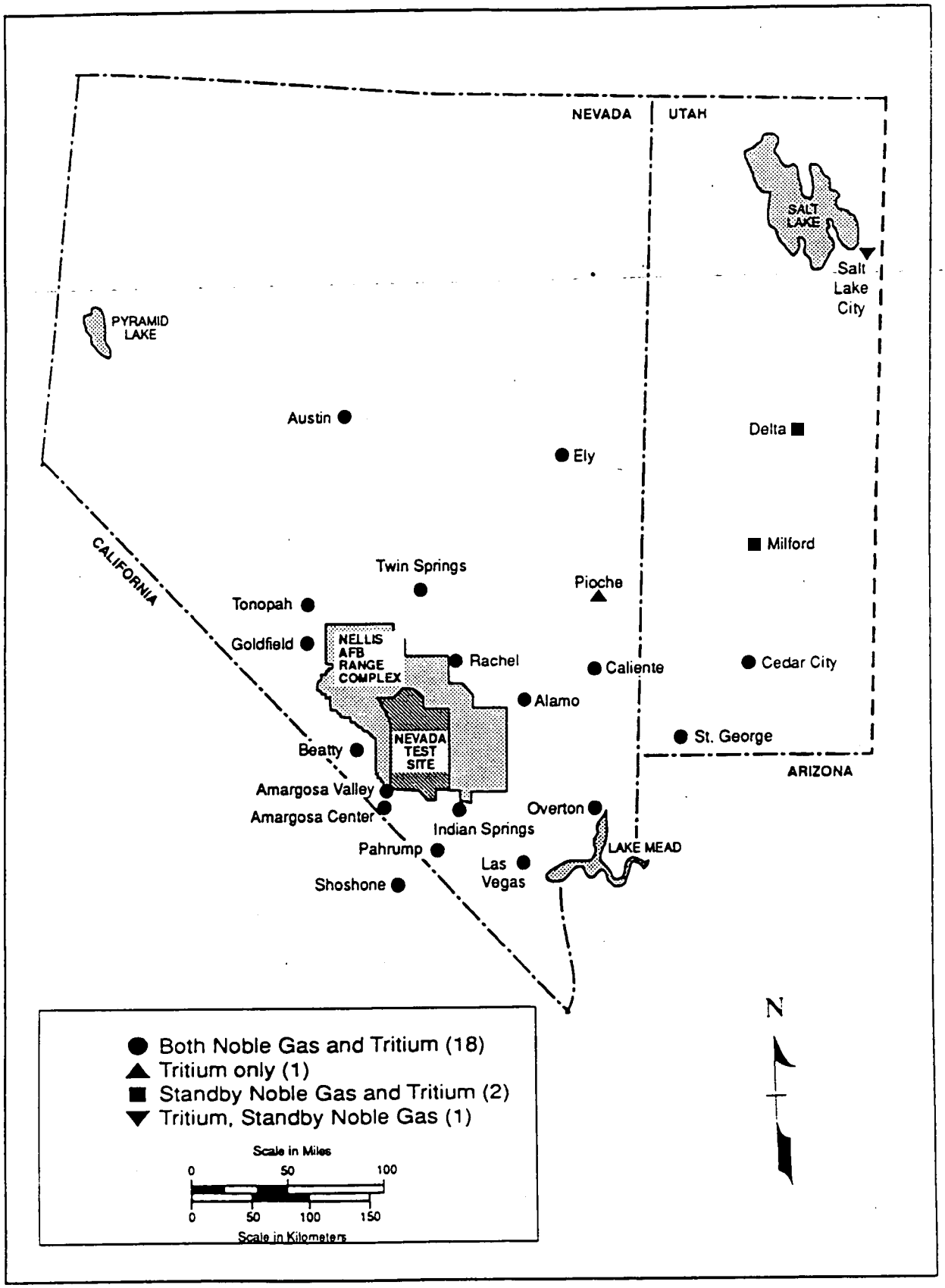

Figure 4.7 Offsite Noble Gas and Tritium Surveillance Network Stations - 1991

adsorbed on the molecular sieve was recovered and the concentration of ^{3}H in the water was determined by liquid scintillation counting.

4.1.2.2 WATER MONITORING

As part of the Long-Term Hydrological Monitoring Program (LTHMP), EMSL-LV scientists routinely collect and analyze water samples from locations on the NTS and from sites in the surrounding offsite areas. Due to the scarcity of surface waters in the region, most of the samples are groundwater, collected from existing wells. Samples from specific locations are collected monthly, biannually, or annually, in accordance with a preset schedule. Virtually all of the drinking water supplies used by the offsite population are represented in the LTHMP samples. Results for the LTHMP samples are discussed in Chapter 9, "Groundwater Protection."

4.1.2.3 MILK SURVEILLANCE NETWORK

In 1991 the Milk Surveillance Network (MSN) consisted of 23 locations within 300 km (186 miles) of the NTS from which samples were scheduled for collection every month. These locations are shown in Figure 4.8. The raw milk was collected in 3.8-liter (1-gallon) Cubitainers and preserved with formaldehyde. In addition, all major milk sheds west of the Mississippi River (represented by 115 locations in 1991) were sampled on an annual basis as part of the Standby Milk Surveillance Network (SMSN). These sampling stations appear in Figure 4.9. Samples from the SMSN were supplied by cooperating state Food and Drug Administration personnel upon request by the EPA regional offices. These samples, also preserved with formaldehyde, were mailed to the EMSL-LV Radioanalysis Laboratory. The annual activation of the SMSN helped maintain readiness and highlighted any trends of increasing radionuclide concentrations in the western states.

All milk samples were analyzed by high-resolution gamma spectroscopy to detect gamma-emitting radionuclides. One sample per quarter for each location in the MSN and samples from two locations in each western state in the SMSN were subjected to radiochemical analysis for ^{3}H by liquid scintillation counting and for ^{89}Sr and ^{90}Sr by the anion exchange method.

4.1.2.4 BIOMONITORING

Samples of muscle, lung, liver, kidney, blood, and bone were collected periodically from cattle purchased from private herds that graze areas adjacent to the NTS. These sampling locations are shown in Figure 4.10. Soft tissues were analyzed for gamma-emitting radionuclides. Bone and liver were analyzed for strontium and plutonium, and blood and kidney were analyzed for ^{3}H. During 1991 four NTS mule deer were collected, sampled, and analyzed similarly. Each fall, bone and kidney samples from desert bighorn sheep killed and donated by licensed hunters in Southern Nevada have been analyzed for strontium, plutonium, and tritium (kidney only). These kinds of samples have been collected and analyzed for up to 33 years to determine long-term trends. During 1991 samples of vegetable produce were collected from farms in St George, Utah (cabbage and carrots), Enterprise, Utah (zucchini squash, and carrots), Beaver Dam, Arizona (onions, and cantaloupe), Alamo, Nevada (carrots, cantaloupe, potatoes, and zucchini squash) and Rachel, Nevada (summer squash, potatoes, and beets). The samples were analyzed by gamma spectroscopy, then by radiochemistry for ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$.

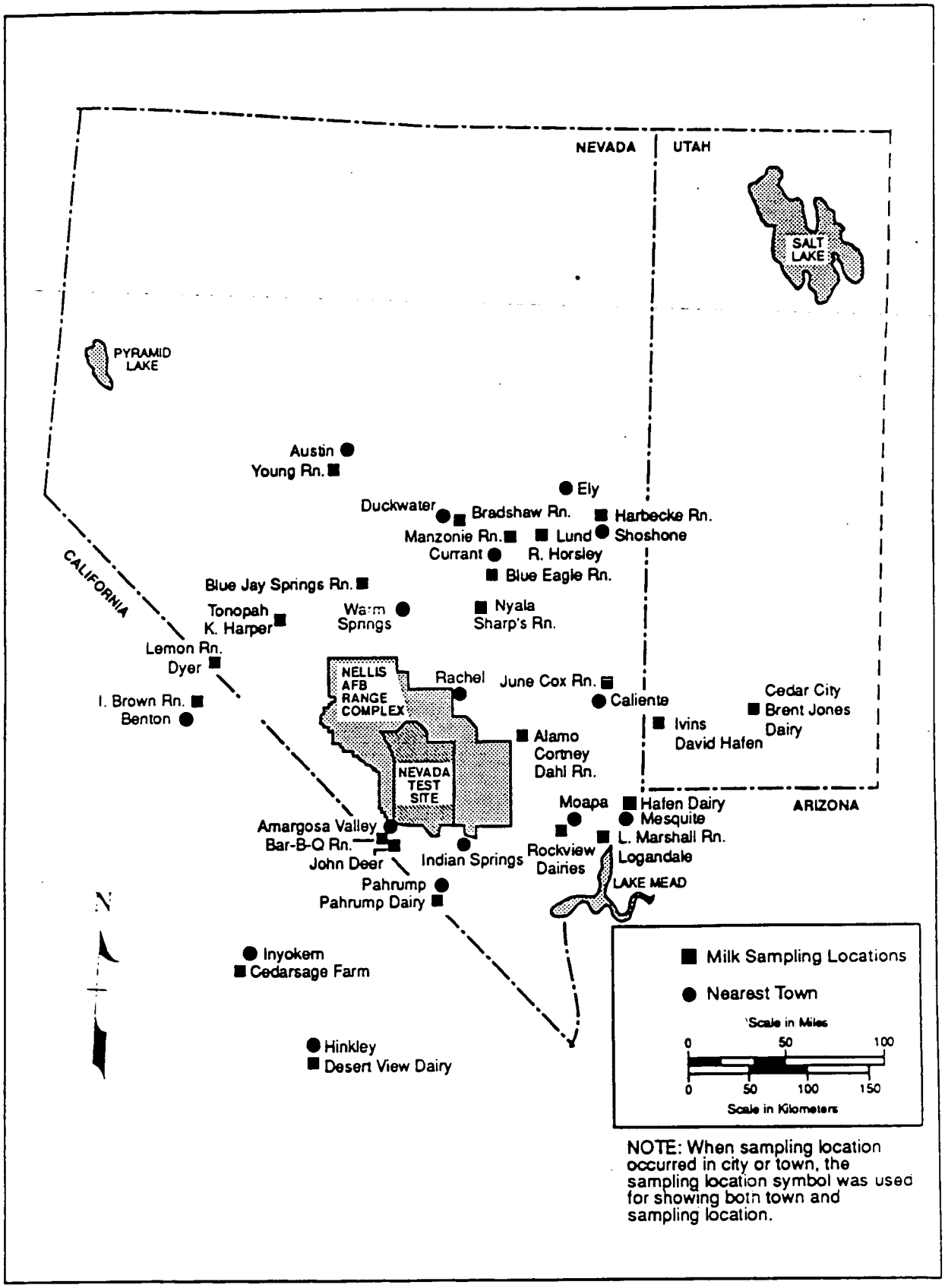

Figure 4.8 Milk Surveillance Network Stations - 1991

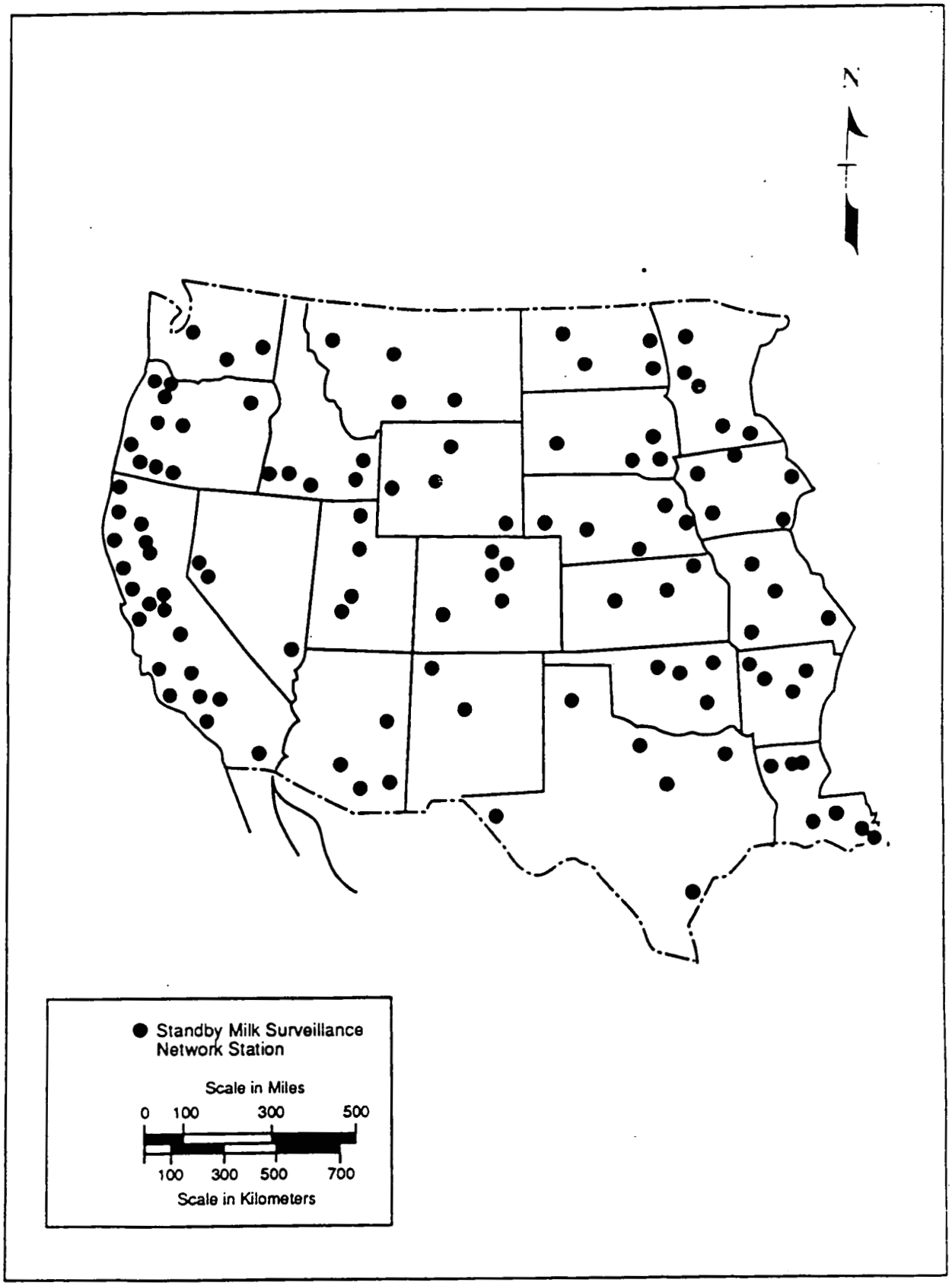

Figure 4.9 Standby Milk Surveillance Network Stations - 1991

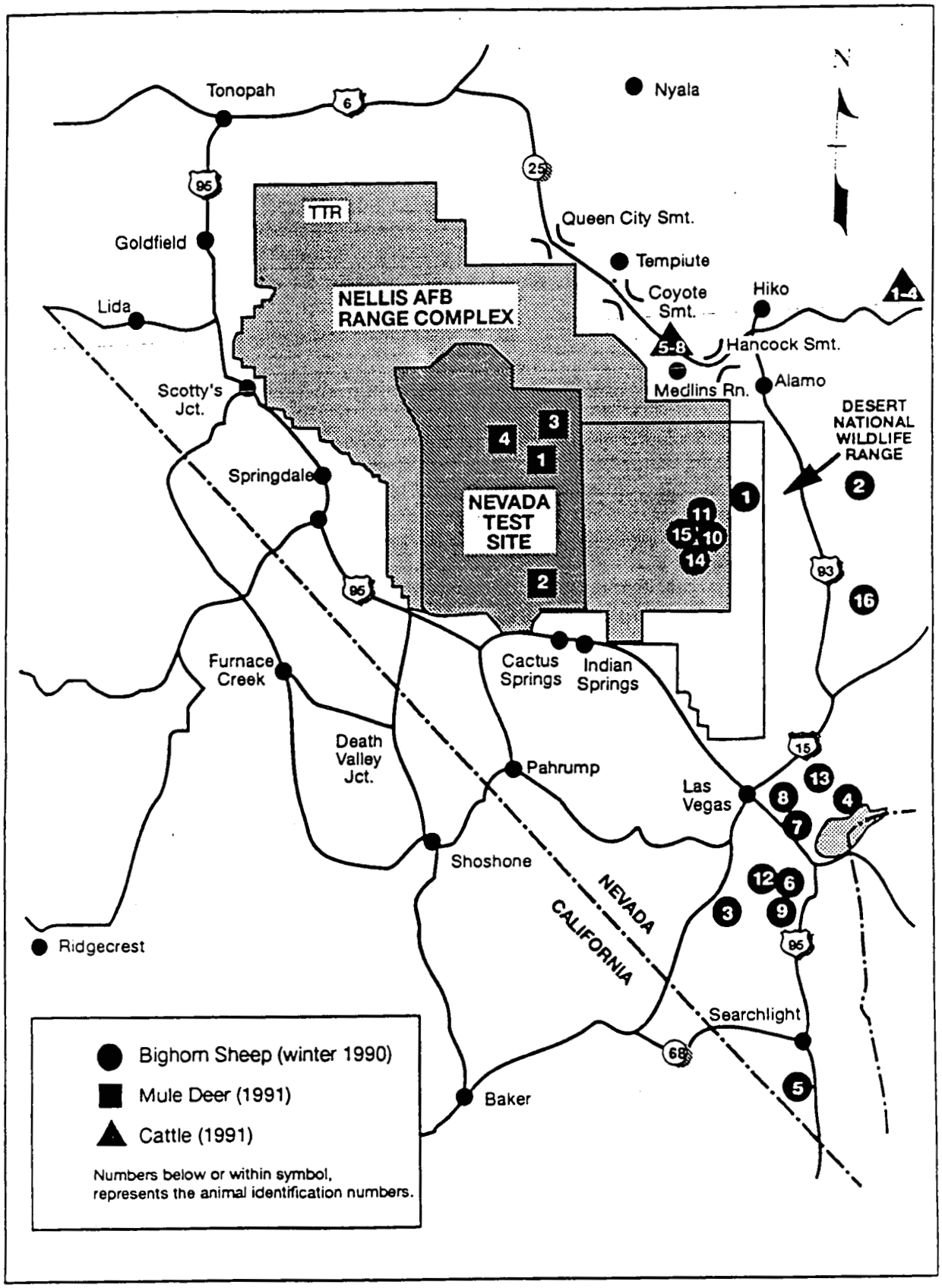

Figure 4.10 Collection Sites for Animals Sampled - 1991

4.1.2.5 EXTERNAL GAMMA EXPOSURE MONITORING

A network of environmental stations and monitored personnel has been established by EMSL-LV in locations encircling the NTS. Monitoring locations in 1991 are shown in Figure 4.11. This arrangement facilitates estimation of average background exposures as well as detection of any increase due to NTS activities. Monitoring of offsite personnel is accomplished with the Panasonic UD-802 dosimeter. This dosimeter contains two elements of $Li_2B_4O_7$:Cu and two of $CaSO_4$:Tm phosphors. The four elements are behind 14, 300, 300, and 1000 mg/cm^2 filtration, respectively. Monitoring of offsite environmental stations is accomplished with the Panasonic UD-814 dosimeter. This dosimeter contains a single element of $Li_2B_4O_7$:Cu and three replicate $CaSO_4$:Tm elements. The first element is filtered by 14 mg/cm^2 of plastic, and the remaining three are filtered by 1000 mg/cm^2 of plastic and lead. The three replicate phosphors are used to provide improved statistics and extended response range.

The EMSL-LV TLD network was designed primarily to measure total ambient gamma exposures at fixed locations. A secondary function of the network was the measurement of exposures to a number of specific individuals living within and outside estimated fallout zones from past nuclear tests at the NTS (offsite residents). Measurement of exposures to specific individuals involved the multiple uncontrollable variables associated with any personnel monitoring program. Measuring environmental ambient gamma exposures in fixed locations provided a reproducible index which could then be easily correlated to the maximum exposure an individual would have received were he continuously present at that location. Monitoring of individuals made possible an estimate of individual exposures and helped to confirm the validity of correlating fixed-site ambient gamma measurements to projected individual exposures.

During 1991 a total of 72 individuals living in 40 localities surrounding the NTS were provided with personnel TLD dosimeters. The TLDs used to monitor individuals are sensitive to beta, gamma, neutron, and low and high-energy X-radiations. The TLDs used to monitor fixed reference background locations are designed to be sensitive only to gamma and high-energy X-radiations. Because personnel dosimeters are cross-referenced to associated fixed reference background TLDs, all personnel exposures are presumed to be due to gamma or high-energy X-radiation. Exposures of this type are numerically equivalent to absorbed dose. Thermoluminescent dosimeters used to monitor individuals are provided in holders which are designed to be worn on the front of an individual's body, between the neck and the waist. When worn in this manner, the TLD may be used to estimate not only ambient gamma radiation exposure but to characterize the absorbed radiation dose an individual wearing the dosimeter may have received. These TLDs are exchanged monthly, but the data are averaged quarterly.

During 1991 a total of 131 offsite stations were monitored to determine background ambient gamma radiation levels. Each station had a custom-designed holder that could hold from one to four Panasonic TLDs. Normal operations involved packaging two TLDs in a heat-sealed bag to provide protection from the elements and placing the dosimeter packet into the fixed station holder. Fixed environmental monitoring TLDs are normally deployed for a period of approximately three months (one calendar quarter). The annual adjusted ambient gamma exposure (mR in one year) is calculated by multiplying the mean daily rate for each station by 365.25.

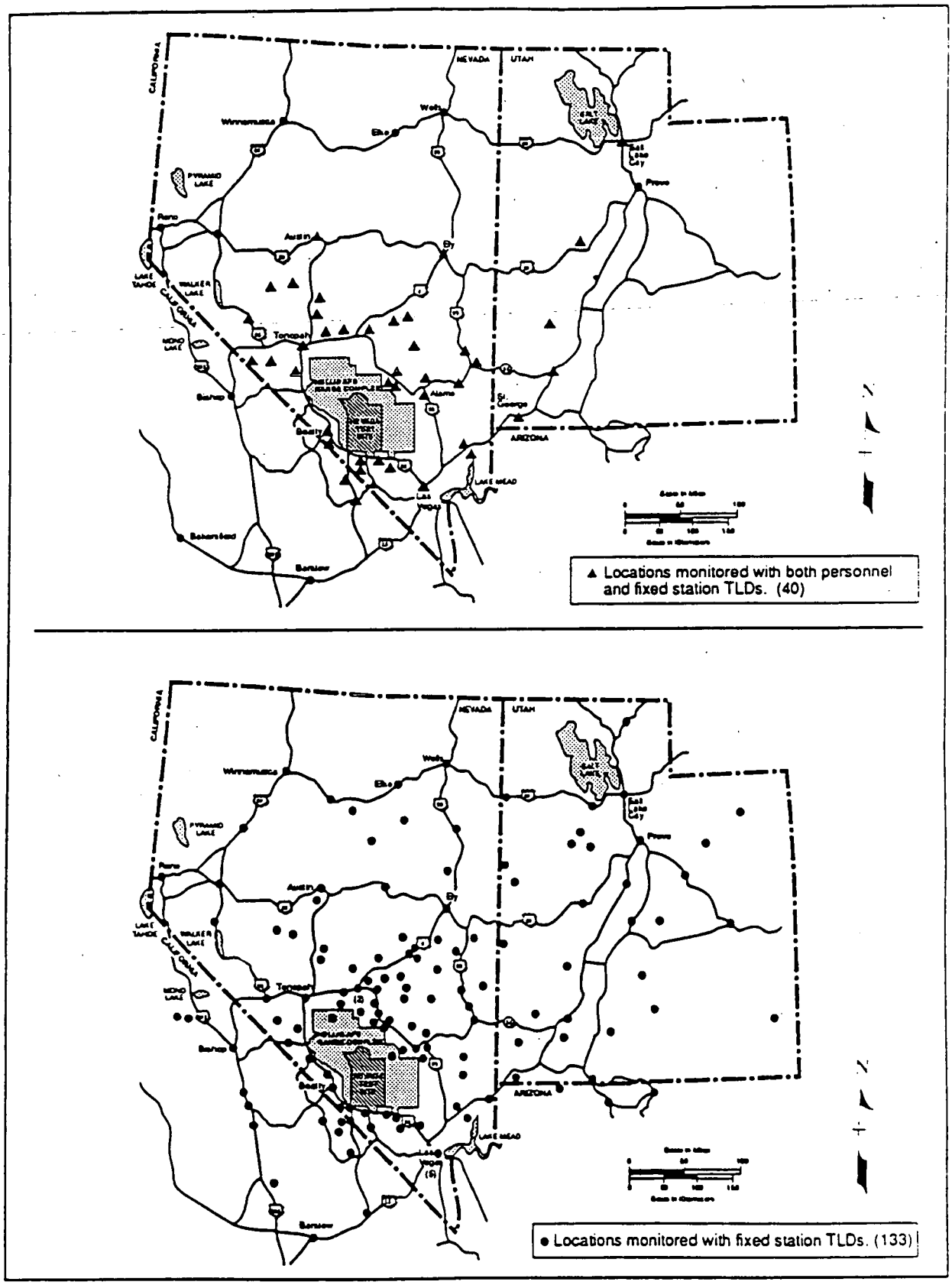

Figure 4.11 Gamma Exposure Monitoring Stations - 1991

During 1991 the EMSL-LV TLD Laboratory was awarded accreditation as a processor of personnel TLDs by the Department of Energy Laboratory Accreditation Program (DOELAP). This accreditation was the culmination of a process extending over a period of approximately one year. The accreditation process began with three rounds of blind exposures to a variety of radiation types and levels ranging from occupational levels through the accident range and included both "pure" radiation fields and mixtures. The purpose of these blind exposures was to test the accuracy, precision, and long-term consistency of overall laboratory performance. The EMSL-LV Laboratory is one of a relatively small number which passed the performance testing phase on their first attempt. The performance testing phase was followed by a rigorous onsite appraisal of laboratory operations, procedures, and quality control both from the perspective of routine operations and to ensure that operations as conducted were appropriate to the overall EMSL-LV radiation safety management mission in support of the U.S. nuclear weapons testing program.

4.1.2.6 PRESSURIZED ION CHAMBER NETWORK

All 29 PIC stations are equipped with satellite telemetry-transmitting equipment. Gamma exposure measurements acquired by the PICs are transmitted via the Geostationary Operational Environmental Satellite (GOES) directly to the NTS and from there to EMSL-LV by dedicated telephone lines. Data are routinely transmitted every four hours unless the gamma exposure rate exceeds 50 μR/h. When the 50 μR/h limit is exceeded for two consecutive 1-minute measurements (e.g., during a calibration check of the PIC sensor unit) the system goes into the alarm mode and transmits a string of nine consecutive 1-minute values on an average of every three minutes (typically varies between 2 and 15 minutes). In addition to telemetry retrieval, the data are also recorded on both magnetic tapes and hardcopy strip charts for 27 of the stations and on magnetic cards for the other two stations. In the unlikely event of an accidental release of radioactivity from the NTS, signals via the satellite telemetry system would provide instantaneous data from all affected PIC locations. The data are evaluated and reported weekly at EMSL-LV as part of routine quality assurance procedures to note trends and anomalies. Data from calibration check sources are also examined to detect trends or anomalies. The locations of all the EMSL-LV PICs are shown on Figure 4.12.

4.1.2.7 OFFSITE DOSIMETRY NETWORK

The whole-body counting facility has been maintained at EMSL-LV since 1966. The facility is equipped to determine the identity and quantity of gamma-emitting radionuclides which might have been inhaled or ingested by offsite residents and others who may have been exposed to 1991 NTS radiation releases. Routine measurement of radionuclides in a person consisted of a 2000-second count with a sensitive radiation detector placed next to a person reclining in one of the two shielded counting rooms. In the other shielded room, a 2000-second count over the lung area is used to determine any americium or plutonium inhalation.

The Offsite Dosimetry Network was initiated in December 1970 to determine levels of radionuclides in some of the families residing in communities and ranches surrounding the NTS. The program consists of radionuclide uptake monitoring, external exposure monitoring, and physical examinations and was designed to estimate exposure to and effects from radioactive emissions from the NTS. The program began with 34 families (142 individuals) residing in general downwind areas from the NTS as well as in areas less subject to fallout. Currently there are 53 families (160 individuals) actively participating in the program. Locations of the 34 families monitored in 1991 are shown in Figure 4.13. The participants

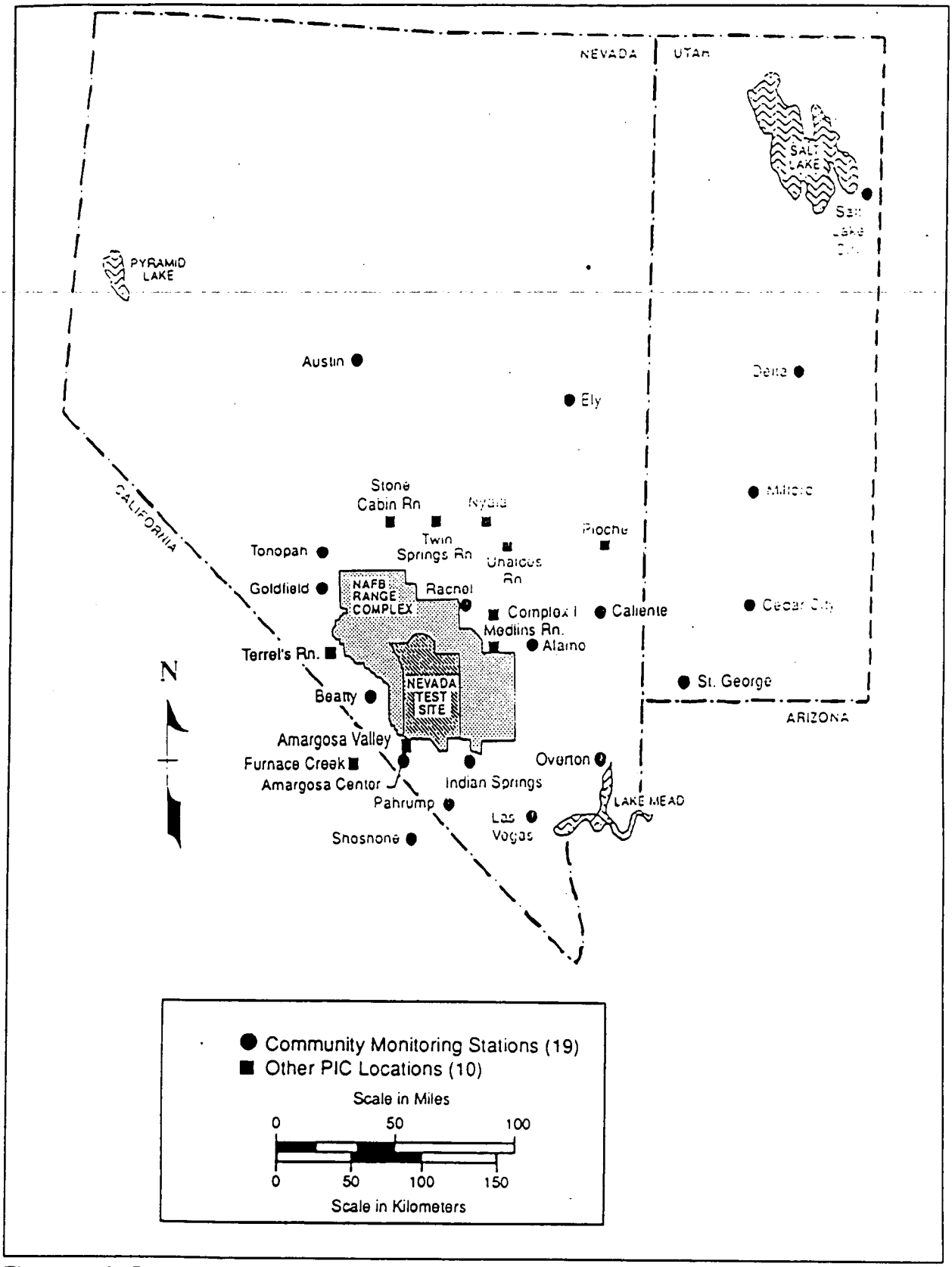

Figure 4.12 Pressurized Ion Chamber Network and Community Radiation Monitoring Stations - 1991

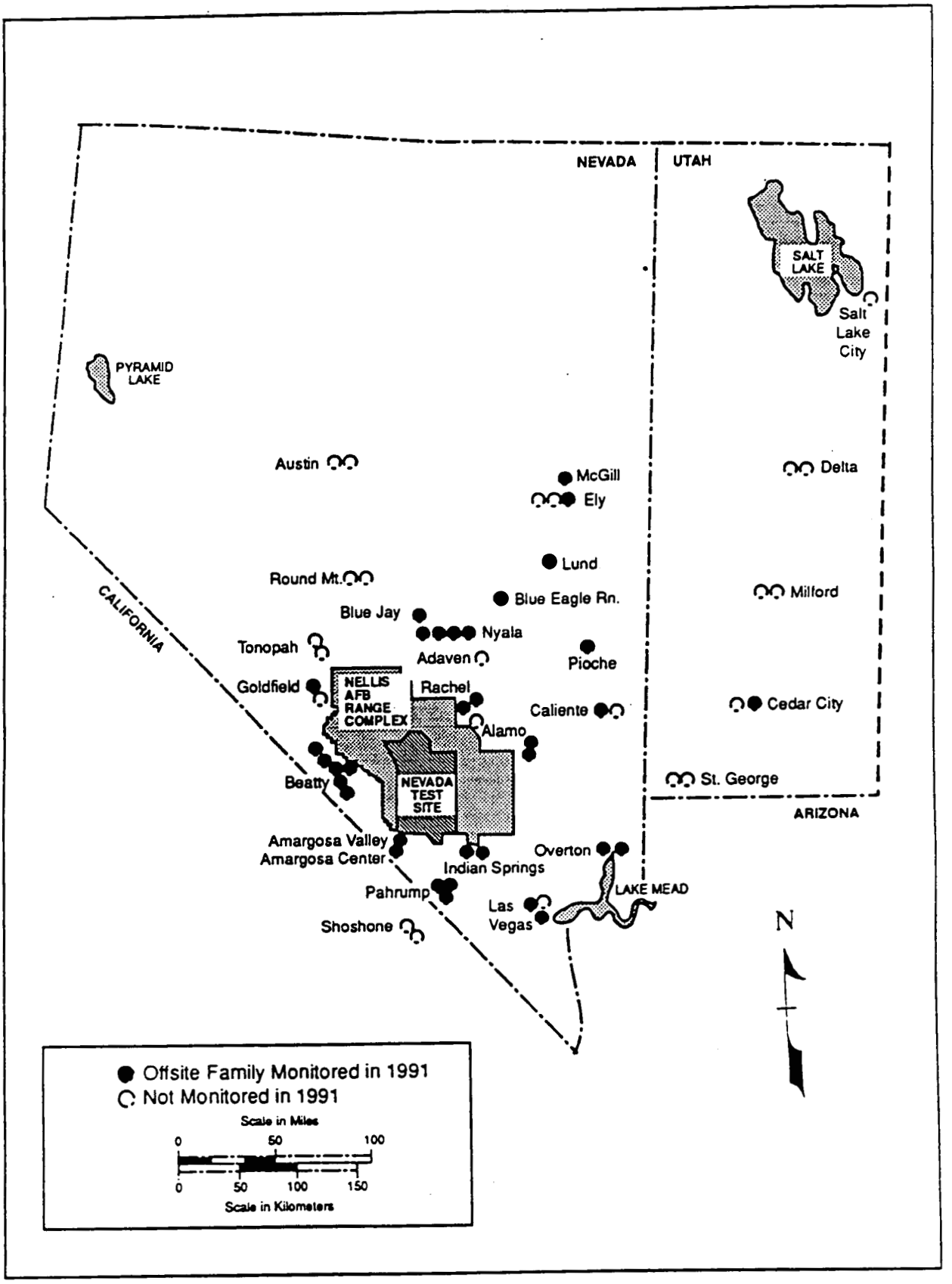

Figure 4.13 Location of Families in the Offsite Dosimetry Program - 1991

travelled to EMSL-LV for a biannual whole-body count. A urine sample was also collected for ^{3}H analysis. At 18-month intervals a health history and physical examination, which included a urinalysis, complete blood count, serology, chest x-ray (three-year intervals), sight screening, audiogram, vital capacity, EKG (if over 40 years old), and thyroid panel, were performed. The individual was then examined by a physician.

Radionuclide uptake monitoring was also performed for EPA employees, DOE contractor employees, and other workers who might have been occupationally exposed as well as for concerned members of the general public. Results of measurements on individuals from Las Vegas and other cities were used for comparison.

4.1.2.8 COMMUNITY RADIATION MONITORING STATIONS (CRMS)

Beginning in 1981 the DOE and EMSL-LV established a network of CRMSs in the offsite areas in order to increase public awareness of radiation monitoring activities. The DOE, through an interagency agreement with the EPA, sponsored the program and contracted with DRI to manage the stations and with the University of Utah to train station managers and their alternates. Each station was operated by local residents, in most cases a science teacher, who was trained in radiation monitoring methods by the University of Utah. Samples were analyzed at the EMSL-LV Radioanalysis Laboratory. Data interpretation was provided by DRI to the communities involved. During 1991 all of the 19 CRMSs, had one of the samplers for the ASN, NGTSN, and TLD networks, a PIC and recorder for immediate readout of external gamma exposure, and a recording barograph. The stations at Milford and Delta were completed with the addition of the noble gas samplers, which were installed in July 1991. All of the equipment was mounted on a stand at a prominent location in each community so the residents were aware of the surveillance and, if interested, could have ready access to the data.

Computer-generated reports of the PIC data were issued weekly for each station. These reports displayed the current weekly average gamma exposure rate, the previous week's and previous year's averages, and the maximum and minimum backgrounds in the U.S. In addition to being posted at each station, copies were sent to appropriate federal and state personnel in California, Nevada, and Utah.

4.1.3 NON-NTS FACILITY MONITORING

Facilities which use radioactive materials or radiation producing equipment, with the potential to expose the general population outside the property line to direct radiation within 10% of the exposure standard for the public (100 mrem/yr) are: SBO during operation of the LINAC; STL, during the operation of the neutron generator; and the LVAO, NLVF High Intensity Source Range. Sealed sources are tested periodically to assure there is no leakage of radioactive material. Documentation of this assessment can be found in the EG&G/EM Radiation Protection Records.

Fence line radiation monitoring at these facilities was conducted during 1991. EG&G/EM uses Panasonic Type UD-814 TLDs. At least two TLDs are at the fence line on each side of the facility. TLDs are exchanged on a quarterly basis with an additional control TLD kept in a source safe.

4.2 NONRADIOLOGICAL MONITORING

Charles W. Burhoe and Scott E. Patton

The 1991 nonradiological monitoring program for the NTS included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and ecological studies. BECAMP conducted studies in 1991 that included wildlife surveys and vegetation trend studies in disturbed and undisturbed areas of the Site. Offsite nonradiological monitoring was conducted in 1991 for 17 tests conducted at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF) on the NTS.

Nonradiological monitoring of non-NTS DOE/NV facilities was limited to wastewater discharges in publicly owned treatment works. This occurred at four EG&G/EM facilities.

4.2.1 NTS OPERATIONS MONITORING

4.2.1.1 ROUTINE MONITORING

As there were no industrial-type production facility operations on the NTS, there was no significant production of nonradiological air emissions or liquid discharges to the environment when compared to many other DOE nuclear facility operations. Sources of potential contaminants were limited to construction support and Site operation activities. This included motor pool facilities; large equipment and drilling rig maintenance areas; cleaning, warehousing, and supply facilities; and general worker support facilities (including lodging and administrative offices) in the Mercury Base Camp, Area 12 Camp, and to a lesser extent in Area 20 and the NTS Control Point Complex in Area 6. The LGFSTF in Area 5 is a source of potential release of nonradiological contaminants to the environment, depending on the individual tests conducted. In 1991 there were 17 tests conducted at this facility, and monitoring was performed to assure these contaminants did not move to offsite areas. Since these monitoring functions are performed by the EMSL-LV at the NTS boundary, monitoring functions for the LGFSTF are described below in 4.2.2, "Offsite Monitoring". Routine nonradiological environmental monitoring on the NTS in 1991 was limited to:

- Sampling of drinking water distribution systems for Safe Drinking Water Act and state of Nevada compliance
- Sewage lagoon influent sampling for Resource Conservation Recovery Act (RCRA) constituents and compliance with state of Nevada operating permits
- Polychlorinated biphenyl (PCB) sampling of electrical transformer oils, soils, and waste oil for Toxic Substance Control Act compliance
- Asbestos sampling in conjunction with asbestos removal and renovation projects and in accordance with occupational safety and National Emission Standards for Hazardous Air Pollutants (NESHAP) compliance
- Sampling of soil, water sediment, waste oil, and other media for RCRA constituents

4.2.1.2 ECOLOGICAL STUDIES

Ecological studies conducted under the DOE/NV-sponsored BECAMP involved monitoring of the flora and fauna on the NTS to assess changes over time in the ecological condition of the NTS and to provide information needed for assessing NTS compliance with environmental laws, regulations, and orders. The monitoring effort (conducted by BECAMP Task 3 - Monitoring of the Flora and Fauna on the NTS) has been arranged into three interrelated phases of work: (1) a series of five non-disturbed control study plots in the test-impacted ecosystems that are monitored at one-, two-, three-, four-, or five-year intervals to establish natural baseline conditions; (2) a series of study plots in representative disturbed areas that are monitored at three- to five-year intervals to determine the impact of disturbance, document site recovery, and investigate natural recovery processes; and (3) a series of wildlife observation plots centered around natural-spring and man-made water-source habitats on the NTS. The monitoring and survey work includes (1) vegetation sampling for the purpose of determining the health status, recovery, and utilization of vegetation in disturbed and undisturbed areas; (2) trapping of rodents and reptiles to determine the condition of individual specimens and the continuity and stability of resident populations; (3) surveys to obtain information concerning resident populations of desert tortoises, kit foxes, rabbits, deer, and feral horses; and (4) the maintenance and preservation of herbarium and biological data archives.

In 1991 the fourth full year of flora and fauna monitoring, 11 ecology monitoring sites 33 plots were surveyed for plants, animals, and reptiles. The 33 plots monitored included (1) 9 for spring ephemeral plants, (2) 10 for perennial plants, (3) 7 for small mammals, and (4) 7 for lizards. Many of these sites contained paired disturbed/undisturbed plots. Monitoring sites surveyed included the control baseline plots in Yucca Flat and Frenchman Flat. Sites in disturbed areas established in 1988 were resurveyed this year; T1 and T3 nuclear blast areas, Waste Consolidation Site 3B, a range fire site in Mid Valley, and the area downwind of the LGFSTF. To date, a total of 27 BECAMP ecology monitoring sites have been established on the NTS with many of the sites containing adjacent control plots.

Monitoring of individual plants and animals on the NTS was conducted in 1991 and included horses, Joshua trees, cacti, junipers, Pinyon pines, and Mojave yuccas. Horse counts were made throughout the summer, one day a month, in regions around springs and well reservoirs, which resulted in a confident estimate of the feral horse population on the NTS. Field observations were made of raptors, waterfowl, lion, deer, and raven on the NTS. Desert tortoises in the Rock Valley/University of California, Los Angeles, study enclosures were surveyed twice in 1991.

4.2.2 OFFSITE MONITORING

The LGFSTF was established in the Frenchman Basin in Area 5 as a basic research tool for studying the dynamics of accidental releases of various hazardous materials and the effectiveness of mitigation procedures. The LGFSTF was designed and equipped to (1) discharge a measured volume of a hazardous fluid at a controlled rate on a specially prepared surface; (2) monitor and record down-wind gaseous concentrations, operating data, and close-in/down-wind meteorological data; and (3) provide a means to control and monitor these functions from a remote location.

DOE/NV provides the facilities, security, and technical support, but all costs are borne by the organization conducting the tests. In 1991 a total of 17 tests were conducted involving

hydrofluoric acid. There were 5 calibration tests and 12 test on personal protective suits. The plans for each test series were examined by an Advisory Panel that consisted of DOE/NV and EMSL-LV professional personnel augmented by personnel from the organization performing the tests.

For each test the EMSL-LV provided an advisor on offsite public health and safety for the Operations Controller's Test Safety Review Panel. At the beginning of each test series and at other tests depending on projected need, a field monitoring technician from the EPA with appropriate air sampling equipment was deployed downwind of the test at the NTS boundary to measure chemical concentrations that may have reached the offsite area. Based on wind direction and speed, the boundary monitor was instructed to collect samples at the time of projected maximum concentration. Samples were collected with a hand-operated Dräger pump and sampling tube appropriate for the chemical being tested. These results are reported in Section 7.1.6. Not all tests were monitored by EPA if professional judgement indicated that, based on previous experience with the chemical and the proposed test parameters, NTS boundary monitoring was unnecessary.

The EPA monitors at the NTS boundary, in contact by two-way radio, were always placed at the projected cloud center line at the time when the cloud was expected at the boundary, so the air samples would be collected at the time and place of maximum concentration. The exact location of the boundary monitor was adjusted during the test by use of two-way radio to ensure that monitoring was performed at the projected cloud center line.

4.2.3 NON-NTS FACILITY MONITORING

Although permits for the eight EG&G/EM non-NTS operations included 29 air pollution, 8 wastewater, and 3 local hazardous waste generator permits, effluent monitoring was limited to wastewater discharges (see below) at 4 sites. For one EG&G operation the monitoring required by the permit was performed exclusively by the regulatory agency. Three other wastewater permits did not include effluent monitoring as a requirement. Reports on the quantities of hazardous materials used in production or disposed of were required by some of the various permits, but these quantities were gleaned from internal records on operating times or use rate, not from any specific routine monitoring effort. A description involving any unexpected emission was required for some permits, but again, monitoring was not required. All results from routine monitoring were within the permit limits, and monitoring activities were limited to the following:

- One grab sample per month was required to be gathered for analysis by the Dublin/San Ramon Sanitation District for Amador Valley Operations. Analysis for pH, chemical oxygen demand, cyanide, metals, and phenols was made on this sample. One yearly grab sample was analyzed by the sanitation district for total toxic organics.

- EG&G/EM, LVAO, North Las Vegas Facility, was require to collect composite samples twice a year from the printed circuit board plating shop effluent and the anodizing shop effluent. Analysis for pH, cyanide, metals and total toxic organics was made on each sample. A biannual monitoring report was submitted to the City of North Las Vegas.

- EG&G/EM, WCO was required to collect grab samples semi-annually of the effluent from sinks used for cleaning parts. Analysis for pH was made on each sample and reported to the Massachusetts Water Resources Authority.

- EG&G/EM, LVAO, Remote Sensing Laboratory, was required to collect a composite sample twice a year from the photo laboratory effluent. Analysis for pH and silver was made on each sample. A biannual monitoring report was submitted to the Clark County Sanitation District. Kirtland Operations was issued a wastewater discharge permit on November 5, 1991 for the Craddock facility, but no periodic monitoring was required until 1992.

4.3 ENVIRONMENTAL PERMITS

Carlton S. Soong

NTS environmental permits included 38 state of Nevada air quality permits involving emissions from construction operation facilities, boilers, storage tanks, and open burning. Six permits for onsite drinking water systems and four for sewage discharges to onsite lagoons or septic tank fields have been issued by the state of Nevada. New revisions to the RCRA Part A and Part B permit applications were initiated in 1991.

Non-NTS EG&G/EM permits included 29 air pollution control permits and 8 sewage discharge permits. Nine EPA Generator Identification (ID) numbers were issued to seven EG&G/EM operations, and three local RCRA-related permits were required at two EG&G/EM operations.

4.3.1 AIR QUALITY PERMITS

Air quality permits were required for numerous locations at the NTS and at two non-NTS facilities.

4.3.1.1 NTS AIR QUALITY PERMITS

Table 4.2 is a listing of state of Nevada air quality operating permits renewed in 1991.

For OP 91-20, the Nevada Air Quality Officer must be notified of each burn no later than five days following the burn, either by telephone or written communication. During 1991 three open burns of explosives-contaminated debris in Area 27 were reported for this permit.

For OP 92-12, the Air Quality Officer must be notified by telephone at least two working days in advance of each training exercise for Class A flammables, and a written summary of each exercise must be submitted within 15 days following the exercise. This summary must include the date, time, duration, exact location, and amount of flammables burned. During 1991 fifteen burns were conducted for radiological emergency response training and one training burn was conducted by onsite fire protection services. One controlled burn for Class A flammables was also held in 1991. A summary of all burns was included in an annual report submitted to the state in October 1991.

New permits to construct were issue by the state of Nevada in 1991 for the Area 1 Portable Destemming System, and for equipment used at the Area 1 Shaker Plant. A new permit to construct was also issued for portable cement bins which are leased and brought to the site on a temporary basis. Table 4.3 is a listing of all air quality permits active in 1991.

4.3.1.2 NON-NTS AIR QUALITY PERMITS

Twenty-eight air pollution control permits have been issued for emission units at EG&G/EM Las Vegas Area Operations, and one Authority to Construct permit has been obtained by the EG&G/EM Special Technologies Laboratory. No expiration dates have been issued with the permits. Annual renewal is contingent upon payment of permit fees. Permits are amended

Table 4.2 Nevada Air Quality Operating Permits Renewed in 1991

Location	Permit	Replaces	Expiration Date
Area 6, Portable Cement Bins	PC 2894	OP 1304/1366	12/05/92
Area 3, Portable Stemming Equipment	PC 2279	OP 1089	02/25/92
Area 1, Concrete Batch Plant	OP 2230	OP 1082	02/19/96
Area 6, Diesel Tank	OP 2275	OP 1085	02/25/96
Area 6, Gasoline Tank	OP 2276	OP 1090	02/25/96
Area 23, Gasoline Tank	OP 2277	OP 1086	02/25/96
Area 23, Diesel Tank	OP 2278	OP 1087	02/25/96
Area 27, Explosive Ordinance Disposal	OP 91-20	OP 90-14	02/28/92
All Areas, NTS	OP 92-12	OP 91-10	11/06/92

Table 4.3 NTS Active Air Quality Permits - 1991

Permit No.	Facility or Operation	Expiration Date
OP 91-20[a]	Open burning, Area 27	02/28/92
OP 92-12[a]	Open burning fire rescue	11/06/92
OP 2187[a]	York-Shipley boiler	11/01/95
OP 2230[a]	Rex LO-GO Concrete Batch Plant	02/19/96
OP 2275[a]	Storage tank, DF #2	02/25/96
OP 2277[a]	Storage tank, unleaded fuel	02/25/96
OP 2278[a]	Storage tank, DF #2	02/25/96
OP 2279[a]	Portable stemming facility, Area 3	02/25/96
OP 2276[a]	Storage tank, unleaded fuel	02/25/96
OP 1287	Aggregate Plant	02/12/92
PC 2894[a]	Portable cement bins, Area 6	12/05/92
OP 1505	LGFSTF	11/02/92
OP 1583	Cafeteria boiler, Ajax boiler	03/23/93
OP 1584	Cafeteria boiler, Ajax boiler	03/23/93
OP 1585	Area 12 Cafeteria boiler, Ajax boiler	03/23/93
OP 1591	Surface area disturbances	03/23/93
OP 1966	Cement storage equipment, Area 6	11/21/94
OP 1972	Shaker Plant	12/04/94
OP 1973	CMI rotary dryer	12/04/94
OP 1974	Cedarapids crusher	12/04/94
OP 1975	Stemming Facility	12/04/94
OP 1976	Stemming Facility	12/04/94
OP 1977	Concrete Batch Plant	12/04/94
OP 1978	Ajax boiler WOFD-6500	12/04/94
OP 1979	Aggregate Mixing/Hopper Plant	12/04/94
OP 2154[a]	Incinerator	10/01/95

(a) New or reissued permits in 1991.

Table 4.3 (NTS Active Air Quality Permits - 1991, cont.)

Permit No.	Facility or Operation	Expiration Date
PC 2706	Portable Destemming System	07/08/92
PC 2707	Portable compressor	07/08/92
PC 2708	Portable compressor	07/08/92
PC 2709	Portable compressor	07/09/92
PC 2710	Portable compressor	07/09/92
PC 2711	Portable compressor	07/09/92
PC 2712	Portable compressor	07/09/92
PC 2823	Portable jaw crusher	09/24/92
PC 2824	Portable screen (C.R.)	09/24/92
PC 2825	Portable screen (Tel.)	09/24/92
PC 2826	Portable pugmill	09/24/92
PC 2895	Temporary portable bins	12/05/92

(a) New or reissued permits in 1991.

and revised only if the situation changes under which the permit has been issued. For the other non-NTS, EG&G/EM operations, no other permits have been required or the facilities have been exempted. Table 4.4 lists each of the required permits.

4.3.2 DRINKING WATER SYSTEM PERMITS

The NTS drinking water permits issued by Nye County as shown in Table 4.5 were renewed with new expiration dates as shown. No drinking water systems were maintained by any non-NTS facility.

4.3.3 SEWAGE DISCHARGE PERMITS

Sewage discharge permits from the state of Nevada are listed in Table 4.6 and require submission of quarterly discharge monitoring reports. No permit violations occurred during 1991. Eight permits, listed in Table 4.7, were required by EG&G/EM non-NTS operations. Three of the eight permits required effluent monitoring during 1991.

4.3.3.1 NTS SEWAGE HAULING INSPECTION

New permit applications were issued by the state of Nevada for sewage hauling trucks for the NTS in November, 1991. The state conducted a prerequisite inspection of these trucks in to determine the cleanliness of the operation, maintenance of the trucks, and disposal procedures. The inspection team visited the disposal sites around NTS and witnessed the trucks and operators in action. No deficiencies were noted.

Table 4.4 Active Air Quality Permits, Non-NTS Facilities - 1991

Permit No.[a]	Facility or Operation
Las Vegas Area Operations	
A06501	Process Equipment, Metal Sanding - Cyclone, Losee Road, NLV
A06502	Process Equipment, Anodizing, Losee Road, NLV
A06504	Diesel Power Generator, Losee Road, NLV
A06506	Process Equipment, Welding, Losee Road, NLV
A06507	Process Equipment, Spray Painting, Losee Road, NLV
A06509	Process Equipment, PC Board Plating, Losee Road, NLV
A06510	Process Equipment, Material Processing, Losee Road, NLV
A06511	Process Equipment, Chemical Processing, Losee Road, NLV
A06512	Cyclone and Stack, Abrasive Blast Facility, Losee Road, NLV
A38701	Emergency Generator, C-1 Complex, Losee Road, NLV
A38702	Process Equipment, Surface Coating, Paint Spraying Facilities, NLV
A38703	Exhaust, Soldering, Building C-1, Losee Road, NLV
A38704	Exhausts, Photo Processing, Building C-1, Losee Road, NLV
A34801	Fuel Burning Equipment, Boiler, NAFB
A34802	Fuel Burning Equipment, Boiler, NAFB
A34803	Fuel Burning Equipment, Boiler, NAFB
A34804	Fuel Burning Equipment, Water Heater, NAFB
A34805	Fuel Burning Equipment, Water Heater, NAFB
A34806	Emergency Generator, NAFB
A34807	Fume Hood, Battery Charging Equipment, NAFB
A34808	Photochemical Mixing & Photo Processing w/Vents, NAFB
A34809	Process Equipment, Paint Spray Booths, NAFB
A06513	Time Saver Ferrous Sander with Torit Dust Cyclone
A06514	Time Saver Aluminum Sander with Torit Dust Cyclone
A06515	Katolight and Kohler Diesel Standby Generators
A06516	Emergency Fire Control Equipment, Cummins Diesel Engine
A06517	Trinco Dry Blast with Dry Bas Dust Filters
A34810	Emergency Fire Control Equipment, Cummins Diesel Engine
Special Technologies Laboratory	
8477	Authority to Construct a 12 Gallon Capacity Vapor Degreaser

(a) An annual fee is paid on these permits; there are no expiration dates.

Table 4.5 NTS Drinking Water Supply System Permits - 1991

Permit No.	Area(s)	Expiration Date
NY-5024-12NC	Area 1	09/30/92
NY-4099-12C	Area 2 & 12	09/30/92
NY-360-12C	Area 23	09/30/92
NY-4098-12NC	Area 25	09/30/92
NY-5000-12NC	Area 6	09/30/92
NY-4097-12NC	Area 3	09/30/92

Table 4.6 NTS Sewage Discharge Permits - 1991

Permit No.	Areas	Expiration Date
NEV87069	Area 2 (1), Area 6 (4)	02/28/94
NEV87076	Area 22, Area 23	02/28/94
NEV87060	Area 6 (1). Area 25 (4)	03/31/93
NEV87059	Area 12	02/28/94

Table 4.7 Non-NTS Sewage Discharge Permits - 1991

Permit No./Location	Date Issued	Expiration Date
Las Vegas Area Operations		
87-2/North Las Vegas Facility*	08/08/89	09/30/91
CCSD-032/Remote Sensing Laboratory	10/26/89	12/23/93
CLV-9/North Las Vegas Facility*	10/01/91	10/01/92
Amador Valley Operations		
3672-101/Pleasanton, California	10/01/91	09/30/93
Santa Barbara Operations		
II-202/Goleta, California	01/01/91	12/31/91
II-204/Goleta, California	01/01/91	12/31/91
Special Technologies Laboratory		
II-225/Santa Barbara, California	01/01/91	12/31/91
Woburn Cathode Ray* Tube Operations		
43 005 732-0	09/28/90	10/31/92
Kirtland Operations		
2175A-R/Craddock Facility	10/15/91	09/01/94

* Effluent monitoring required by permittee

4.3.3.2 NTS SEWAGE LAGOON OPERATIONS AND MAINTENANCE (O&M) MANUALS

State approval for the Area 23 sewage lagoon O&M manual was received in March 1992. The remaining NTS O&M manuals will be revised to this standard and submitted for approval in 1992.

4.3.3.3 NON-NTS SEWAGE PERMITS

Sewage permits were required for six of the eight non-NTS EG&G/EM operations. This included two permits at the Las Vegas Area Operations facilities, one at the Amador Valley Operations facility, one at the Kirtland Operations, two at the Santa Barbara Operations facility, one at the Special Technologies Laboratory, and one at the Woburn Cathode Ray Tube Operations facility. These are listed in Table 4.7. Each was issued by the county or community in which the facility was located.

4.3.4 INJECTION WELL PERMITS

Subsequent to the October 1989 submittal of the discharge permit application for the Area 1 injection wells, it was decided in 1990 that underground injection would not be pursued as a viable disposal option for wastewater at the NTS. Also, one injection well at the EG&G/EM facility in Woburn, Massachusetts is subject to state overview. Per state guidance, the permitting process is on hold until a state engineer can inspect the injection well.

4.3.5 RCRA PERMITS

4.3.5.1 NTS OPERATIONS

REECo continues to operate under EPA ID Number NV3890090001 as the operator for the NTS.

Closure activities at the Area 23 Landfill continued in 1992. Extensive trenching to accurately locate waste trenches was conducted and a report will be issued in 1992. State of Nevada inspectors monitored trenching operations. A revised work plan will be submitted based on the findings.

Two other closure plans, for U3fi Injection Well and the Area 6 Steam Cleaning Effluent Ponds, were submitted to the state in 1991. State comments were received in December and responses are being prepared.

New revisions to the RCRA Part A and Part B applications were initiated by Raytheon Services Nevada in 1991 (see Section 3.5.1.1).

4.3.5.2 NON-NTS FACILITIES

Nine EPA Generator ID numbers have been issued to seven EG&G/EM operations. In addition, three local permits were required at two EG&G/EM operations. Hazardous waste is managed at these locations using satellite accumulation areas and a 90-day or longer for waste accumulation area. All hazardous and industrial chemical wastes are transported to RCRA-permitted facilities for approved treatment and/or disposal.

4.3.6 ENDANGERED SPECIES ACT PERMITS

Federal and state permits have been issued to NTS entities for study of endangered species. (All EG&G/EM non-NTS facilities are located in existing metropolitan areas and are not subject to the Endangered Species Act.) These biological studies include ongoing research on the desert tortoise. Reports are filed with the state of Nevada as stipulated by the permits.

In order to continue desert tortoise studies at the NTS, REECo applied for an endangered species permit from the U.S. Fish and Wildlife Service in 1989 and received the new permit in 1991.

5.0 RADIOLOGICAL MONITORING RESULTS

Radiological environmental monitoring results from onsite environmental programs included (1) effluent sampling results for airborne emissions and liquid discharges to containment ponds and (2) environmental sampling and study results for onsite surveillance conducted by Reynolds Electrical & Engineering Co., Inc., (REECo). Offsite surveillance was conducted by the EPA Environmental Monitoring Systems Laboratory - Las Vegas (EMSL-LV). Onsite monitoring results indicated that environmental concentrations of radioactivity resulting from NTS air emissions were statistically no different than background except in the immediate vicinity of the emissions. These short-term emissions over a period of hours or days, and radioactive liquid discharges to onsite containment ponds, produced concentrations that were only a small fraction of a percent above background in terms of potential exposure of onsite workers. Offsite monitoring indicated that environmental radionuclide concentrations and exposure rates were statistically no different than background, with no measurable exposure of offsite residents from current NTS test operations. Small amounts of radioactivity were detected in animal samples collected onsite and in some garden vegetables collected offsite.

5.1 RADIOLOGICAL EFFLUENT MONITORING

Fred D. Ferate and Omer W. Mullen

Monitoring efforts for potential airborne radioactive effluents at the NTS consisted primarily of intensive air sampling and radiation detection through instrumentation deployed in the vicinity of nuclear tests during and following the tests. This instrumentation showed no prompt release of radioactivity occurred after any of the eight announced tests in 1991. Subsequent gas seepage occurred as a result of post-test operations. These occurred during three post-test operations, and resulted in releases of approximately 1.3 curies of gaseous radioactivity. Air samples collected in and around the Area 5 Radioactive Waste Management Site (RWMS) indicated that no measurable radioactivity was detectable away from the area, yet trace amounts of tritium were detected at its boundary. Samples from the Area 3 Bulk Waste Management Facility (BWMF), however, showed above-background levels of $^{239+240}Pu$. The primary liquid effluents were Rainier Mesa tunnel seepage water collected in containment ponds at the tunnel mouths. Influent to these ponds essentially contained only tritium (^{3}H), with a total tunnel discharge of 1700 curies. Additionally, 120 curies were released in water discharged to a surface pond from a research well used in a radionuclide migration study. This well was permanently shut down in August of 1991.

5.1.1 EFFLUENT MONITORING PLAN

As required by DOE Order 5400.1, the NTS Environmental Monitoring Plan was developed and published (DOE/NV/10630-28,1991). An important part of the Plan is the onsite Effluent Monitoring Plan, in which the Area 12 tunnels, the Area 6 Decontamination Facility, nuclear test sites, Radioactive Waste Management Sites, and all other potential effluent sites throughout the NTS have been assessed for their potential to contribute to the public dose.

Airborne radioactive effluents are the emissions on the NTS with the greatest potential for reaching members of the public. All radioactive liquid effluents from activities on the NTS are contained within its boundaries. For all activities on the NTS, the estimated effective dose equivalent to any member of the public from all airborne radionuclide emissions is less than 0.1 mrem/year. In accordance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements set forth in 40 CFR 61.93(b)(4)(ii), and Regulatory Guide DOE/EH-0173T, compliance with these requirements will be achieved by periodic measurements of effluents to confirm the low dose levels. For consistency with past practices, the monitoring methods and procedures developed over the years are being continued with changes to be introduced as conditions warrant.

To meet 40 CFR 61 requirements, an isokinetic sampling system was installed in September 1991 near the entrance to P Tunnel in Area 12, for the purpose of making confirmatory measurements of airborne effluents from the P Tunnel ventilation duct. No sampling data from this system are described in this report since testing and adjustments of the system were still in progress at the end of 1991.

5.1.2 AIRBORNE EFFLUENTS

The majority of radiological air effluents at the NTS in 1991 originated from underground nuclear explosive tests conducted by NTS user organizations; the Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), and Defense Nuclear Agency (DNA) of the Department of Defense (DOD). (See Table 5.1 for a listing of all onsite effluent releases.) Each user organization performed effluent monitoring at the time of detonation and continued monitoring until all research activities were completed. Upon request, REECo performed radioactive noble gas monitoring at test sites within Rainier Mesa and Pahute Mesa. This involved deployment of one or more noble gas samplers near surface ground zeros (SGZs) to monitor possible release of radioactive gases. Considering all radionuclides detected, approximately 1.3 curies were released as airborne effluents.

An increase in efforts to monitor radioactive air emissions at the NTS began in November 1988 as a result of requirements in DOE Order 5400.1, DOE Order 5400.5, and regulatory guide DOE/EH-0173T, as well as from EPA requirements in the National Emission Standards for Hazardous Air Pollutants, 40 CFR 61. Known and potential effluent sources throughout the NTS have been assessed for their potential to contribute to public dose and have been considered in designing the Site Effluent Monitoring Plan, which forms part of the Environmental Monitoring Plan, Nevada Test Site and Support Facilities, DOE/NV/10630-28, published in November 1991.

5.1.2.1 NUCLEAR EVENT MONITORING

This section is a summary of the specific nuclear event monitoring conducted at the NTS prior to and after each event, as well as routine effluent monitoring on the NTS. The various

Table 5.1 NTS Radionuclide Emissions - 1991

Airborne Effluent Releases

Event or Facility Name (Airborne (Releases)	Curies[a]									
	^{3}H	^{37}Ar	^{39}Ar	^{85}Kr	^{127}Xe	^{129m}Xe	^{131m}Xe	^{133}Xe	^{133m}Xe	^{131}I
Area 5, RWMS	5.0×10^{-1}									
Area 3, LUBBOCK								8.3×10^{-2}		
Area 12, P Tunnel	1.4×10^{-5}	4.5×10^{-1}	2.1×10^{-4}	6.6×10^{-3} (b)	6.6×10^{-6}	5.2×10^{-5}	7.0×10^{-3}	2.7×10^{-1}	3.8×10^{-3}	
Area 19, BEXAR								5.0×10^{-1}		1.0×10^{-4}
TOTAL	5.0×10^{-1}	4.5×10^{-1}	2.1×10^{-4}	6.6×10^{-3}	6.6×10^{-6}	5.2×10^{-5}	7.0×10^{-3}	8.5×10^{-1}	3.8×10^{-3}	1.0×10^{-4}

Liquid Effluent Releases

Containment and Radionuclide Migration (RNM) Ponds	Curies[a]					
	Gross Beta	^{3}H	^{90}Sr	^{137}Cs	^{238}Pu	$^{239+240}Pu$
Area 5, U5eRNM2S		1.2×10^{2}				
Area 6, Decontamination Pad Pond	2.6×10^{-4}	1.8×10^{-2}	1.0×10^{-5}		2.7×10^{-7}	3.0×10^{-7}
Area 12, E Tunnel	1.9×10^{-3}	5.0×10^{1}	1.1×10^{-4}	2.7×10^{-3}	1.7×10^{-5}	1.4×10^{-4}
Area 12, N Tunnel	1.3×10^{-3}	1.9×10^{1}			1.8×10^{-6}	1.4×10^{-6}
Area 12, T Tunnel	3.7×10^{-2}	1.7×10^{3}	4.4×10^{-4}	1.0×10^{-2}	7.7×10^{-6}	1.3×10^{-4}
TOTAL	4.0×10^{-2}	1.8×10^{3}	5.6×10^{-4}	1.3×10^{-2}	2.7×10^{-5}	2.7×10^{-4}

(a) Multiply by 3.7×10^{10} to obtain Bq. Calculated releases of transuranics from air sampler data and from laboratory losses are shown in Table 1.1.

(b) Environmental monitoring in Area 20 detected an average ^{85}Kr of 8 pCi/m^3 above the network average. Probably due to seepage as source term is indeterminate. A person standing at the sampler location all year would have received a dose of only 2.7×10^{-4} mrem.

events, by name, and the results of measurements taken at each event site are presented in Table 5.2. This section also discusses other NTS facilities which are monitored for effluents on a routine basis.

Air emissions from nuclear testing operations consisted primarily of radioactive noble gases and ^{3}H released during post-test drill-back, mine-back, or sampling operations following three 1991 underground nuclear tests. None of the tests resulted in a prompt release or venting (i.e., a release of radioactive materials within 60 minutes of the nuclear test). Air emissions were monitored for source characterization and operational safety as well as environmental monitoring purposes.

Onsite radiological safety support, including monitoring for effluents (air emissions), were provided during the eight announced nuclear tests conducted at the NTS in 1991 by NTS user organizations (LANL, LLNL, and DNA). Routine air sampling had been conducted for emissions from the G Tunnel complex in previous years. As the ventilation system for the G Tunnel complex was closed down in September 1990, no sampling of G Tunnel effluents was performed in 1991.

The test-associated services included detecting, recording, evaluating, and reporting of radiological conditions prior to, during, and for an extended period after each test and provision of aerial monitoring teams during each test to detect airborne releases. Personnel equipped with specialized collection and measurement instruments were prepared to respond rapidly should an accidental release of airborne radioactive materials have occurred from the underground test.

Complete radiological safety coverage was also provided during post-event drillback (for vertical shaft testing) and mineback (for tunnel testing) operations. These activities involved either drilling or mining into the vicinity of the nuclear detonation to acquire samples of test-associated material. These operations bore a potential for releasing radioactive gases to the atmosphere. Seepage of these gases to the surface might also have occurred. Methods of data accumulation included recording telemetered radiation measurements from the test area, air sampling, worker bioassays, and, if warranted, whole-body counting.

The radiation detection array surrounding an SGZ was positioned to provide the first telemetered data if venting were to have occurred following detonation of a nuclear device. A typical array for a vertical shaft event is shown in Figure 5.1. Each gamma-sensitive, ion-chamber detector was linked by microwave and hard-wire communications to a console in one of two buildings at the NTS Control Point and/or the Control and Data Acquisition Center. The console also displayed information from each of the permanent telemetered remote area monitor (RAM) arrays. The levels were displayed on each console and the time of the measurement, in minutes after zero time (detonation), were recorded and displayed.

Following each test, when control of the test area was released by the DOE Test Controller, REECo personnel accompanied the Test Group Director's inspection party entering the potential radiological exclusion area to perform initial surveys. Radiation measurements, obtained using portable detection instruments, plus measurements of time and location were recorded on survey forms and the information reported by radio. Survey locations were determined from roadside numbered reference stakes and road junctions. Maps showing the locations of these reference stakes in relation to roads and landmarks were provided to participating test groups. Radiation exposure rates obtained with portable instruments usually were made at waist-high level (approximately one meter above the ground).

Table 5.2 Nuclear Event Release Summary - 1991

Announced 1991 Nuclear Events - Nevada Test Site

Event Name	Test Org.	Hole/ Area No.	Location	Date/ Time of Event	Prompt Release?	Telemetry Measurement Start	Telemetry Measurement Stop	Initial Radiation Survey Began	Initial Radiation Survey Ended	Maximum Exposure Rate	Release Information
COSO	LLNL	U4an Area 4	Yucca Basin	03/08/91 1303 hrs	No	03/08/91 1304 hrs	03/09/91 1304 hrs	03/08/91 1318 hrs	03/08/91 1408 hrs	0.05 mR/h	None detected.
BEXAR	LANL	U19ba Area 19	Pahute Mesa	04/04/91 1100 hrs	No	04/04/91 1100 hrs	04/05/91 1134 hrs	04/04/91 1158 hrs	04/04/91 1231 hrs	0.05 mR/h	^{131}I and ^{133}Xe released. See Table 5.1.
MONTELLO	LLNL	U20bf Area 20	Pahute Mesa	04/16/91 0830 hrs	No	04/16/91 0831 hrs	04/17/91 0832 hrs	04/16/91 0900 hrs	04/16/91 1000 hrs	0.05 mR/h	None detected.
FLOYDADA	LANL	U7cb Area 7	Yucca Basin	08/15/91 0900 hrs	No	08/15/91 0900 hrs	08/16/91 0900 hrs	08/15/91 1020 hrs	08/15/91 1042 hrs	0.05 mR/h	None detected.
HOYA	LLNL	U20be Area 20	Pahute Mesa	09/14/91 1200 hrs	No	09/14/91 1201 hrs	09/15/91 1200 hrs	09/14/91 1241 hrs	09/14/91 1357 hrs	0.05 mR/h	None detected.
DISTANT ZENITH	DNA	U12p.04 Area 12	Rainier Mesa	09/19/91 0930 hrs	No	09/19/91 0930 hrs	09/23/91 0930 hrs	09/19/91 1038 hrs	09/19/91 1108 hrs	0.05 mR/h	^{3}H and noble gases released. See Table 5.1.
LUBBOCK	LANL	U3mt Area 3	Yucca Basin	10/18/91 1212 hrs	No	******** ********	******** ********	10/18/91 1332 hrs	10/18/91 1410 hrs	0.05 mR/h	^{133}Xe released. See Table 5.1.
BRISTOL	LLNL	U4av Area 4	Yucca Basin	11/26/91 1035 hrs	No	11/26/91 1036 hrs	11/27/91 1040 hrs	11/26/91 1113 hrs	11/26/91 1145 hrs	0.05 mR/h	None detected.

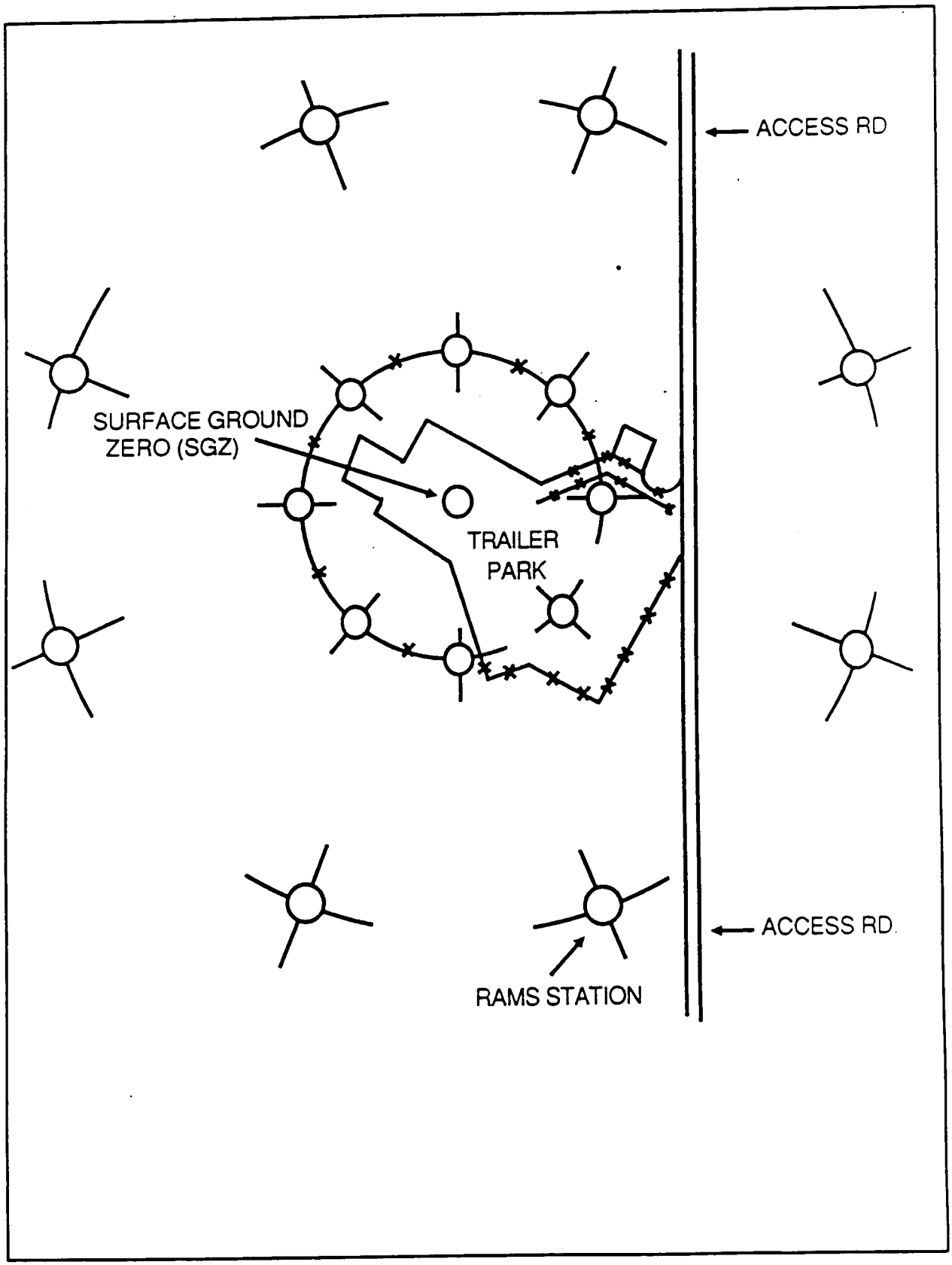

Figure 5.1 Typical RAM Array for a Nuclear Test. *The stations on the inner arc are at a radius of 320 feet from SGZ; the outer arc stations are at 1000 feet from SGZ*

During the post-event drillback and mining activities, REECo personnel maintained continuous environmental surveillance in the work area. For drillback coverage, radiation detector probes were placed in strategic locations in the work areas and connected to recorders and alarms to warn of increases in radiation levels. Radiation monitoring personnel using portable instruments periodically checked work area radiation levels and issued protective equipment to, or evacuated, area personnel when necessary. For containment of radioactive material releases to the atmosphere during drillback, LANL utilized a pressurized recirculation system. LLNL used a ventline filter system designed to trap radioactive particulates released from the drill casing. In the ventline system, trapped radioactive material was allowed to decay under controlled conditions. For DNA tunnel operations, the effluent was passed through a charcoal/ high-efficiency particulate aerosol (HEPA) filter system before release. This trapped radioactive material was also allowed to decay under controlled conditions.

NOBLE GAS MONITORING

Portable air samplers were set up surrounding or in the vicinity of the SGZ for the three events conducted on Pahute Mesa during 1991. These air samplers were similar to the samplers used to monitor noble gases as part of the Site-wide environmental surveillance program (see Section 5.2.1). The only modification to the sampler was that those sampling units deployed at the event sites could operate for several weeks on battery power. Otherwise the samples were taken and analyzed using the same methods described for the environmental surveillance noble gas samplers.

Typically, two noble gas samplers were deployed, one near a RAM station in the prevailing upwind direction and the other in the prevailing downwind direction from ground zero. This deployment at RAM stations was performed to establish a common reference point with the RAM locations. Predominant wind direction and ease of access were the two main factors used when choosing the appropriate RAM station.

Data results for the three events monitored are presented in Appendix E, "Radioactive Noble Gases in Air Onsite," Tables E.1, E.2 and E.4. The maximum concentrations of ^{85}Kr and ^{133}Xe measured in samples collected at the locations indicated in these tables were less than 6×10^{-5} percent and less than 3×10^{-4} percent, respectively, of the Derived Air Concentration (1×10^{-4} µCi/mL) for these radionuclides. Sampling at these locations ranged from 2 to 9 weeks following the corresponding events to assess any late-time, post-test seepage.

5.1.2.2 TUNNEL COMPLEX EFFLUENT

Except for the event-related monitoring of the P Tunnel complex ventilation system during planned releases following the event DISTANT ZENITH, the results of which are described in Tables 5.1 and 5.2, and test measurements associated with the installation of the isokinetic sampling system near the P Tunnel entrance, no monitoring was done of the tunnel complexes for airborne effluents in 1991. Previous monitoring by the Sandia National Laboratories of tritiated water vapor in the G Tunnel complex ventilation system was terminated in September of 1990 when the ventilation system was shut down.

5.1.2.3 RADIOACTIVE WASTE MANAGEMENT SITES

Two permanent particulate/halogen samplers were located within the disposal pits at the RWMS in Area 5. The annual average concentration of samples taken within Pits #3 and #4 in Area 5 were both 2.0×10^{-14} µCi/mL of gross beta activity. The NTS annual average gross

beta concentration, not including the Area 5 samplers distributed around the disposal site, was1.7 x 10^{-14} µCi/mL. There is no statistical difference between these averages at the five percent significance level.

Analysis of samples taken within Pit #3 and #4 indicate that the operations in the RWMS are not contributing radiological effluents in concentrations statistically different at the five percent significance level from concentration levels present in the NTS environment. Average annual gross beta and plutonium results from all the samples collected at the RWMS facility are displayed in Figure 5.2.

Nine ^{3}H samplers were located surrounding the RWMS. These samplers are placed near the perimeter berm of the disposal site as seen in Figure 5.3. The annual average ^{3}H concentration for the nine stations was 7.5 x 10^{-6} pCi/mL. This value is less than 0.008 percent of the Derived Concentration Guide for tritiated water vapor in air. The results indicate the waste disposal operations at the RWMS did not contribute significant levels of tritiated water vapor to the NTS environment. The annual average ^{3}H concentrations from the samplers surrounding the RWMS facility are displayed in Figure 5.3.

The results from thermoluminescent dosimeters (TLDs) deployed surrounding the RWMS facility indicated that the gamma exposure rates measured in 1991 were not statistically different from the levels measured in 1990. A discussion of historical trends of environmental gamma exposure as measured by environmental TLDs is given in Volume II, Appendix G. Although a statistical analysis shows that there are differences between NTS areas in levels of environmental exposure, there were not enough data to determine the nature of the differences. Nevertheless, an examination of annual average exposure rates (see Table F.4 in Volume II, Appendix F, "Onsite Thermoluminescent Dosimeter Data) shows that the gamma exposure rates detected at the RWMS perimeter are not atypical of gamma measurements taken at other locations on the NTS. The (RWMS perimeter) exposure rates in mR/day are shown in Figure 5.3. The statistical analysis is presented in Volume II, Appendix F, "Onsite Thermoluminescent Dosimeter Data."

The Area 3 Bulk Waste Management Facility (BWMF) is used for disposal of radiologically contaminated waste that is unsuitable for normal low-level waste disposal. This waste is buried in subsidence craters much like waste is buried at the Area 5 RWMS. The BWMF is surrounded by four permanent particulate/halogen samplers located approximately north, south, east, and west of the burial pit. Several TLDs were distributed at the BWMF and surrounding areas. The gross beta annual average at the BWMF of 1.9 x 10^{-14} µCi/mL was identical to the 1990 average, and was not statistically different at the five percent significance level from the Site-wide average. However, $^{239+240}Pu$ results indicated that levels of these radionuclides at the BWMF were consistently above the NTS average (see Appendix A of Volume II). During disposal of earth contaminated with plutonium at the BWMF, a small fraction becomes suspended in air. As such, the elevated $^{239+240}Pu$ levels indicated that the BWMF was a diffuse source of effluents. Air sampling results are displayed in Section 5.2.1.2, Tables 5.5 and 5.6, and TLD results are listed and discussed in Appendix F of Volume II.

5.1.3 LIQUID EFFLUENTS

Liquid effluents at the NTS originated from tunnels, research studies of radionuclide movement through groundwater, and cleanup of radiologically contaminated equipment. Typically, all liquid discharges within the NTS were held in containment ponds. Monthly grab

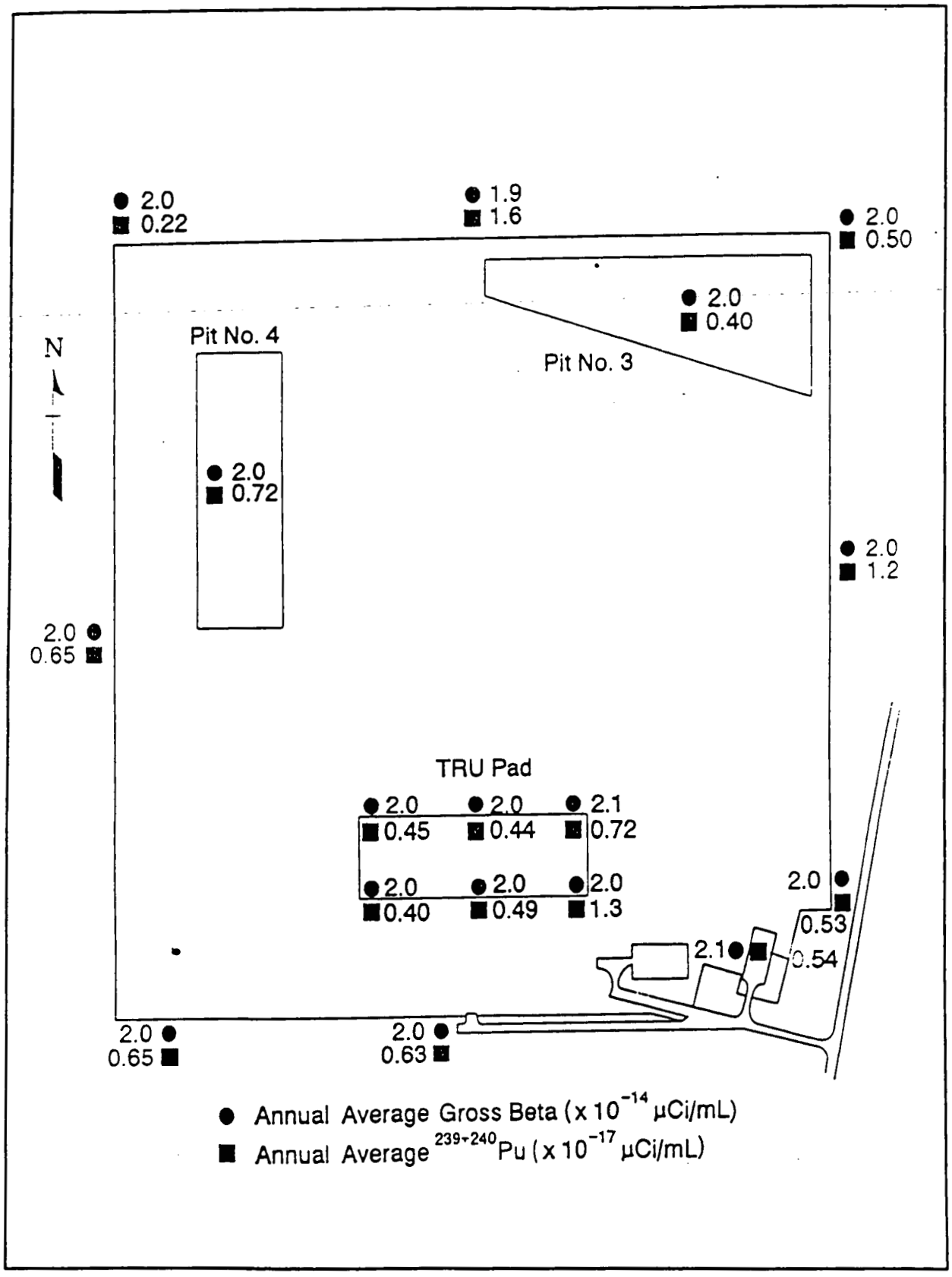

Figure 5.2 RWMS Air Sampling Annual Average Results - 1991

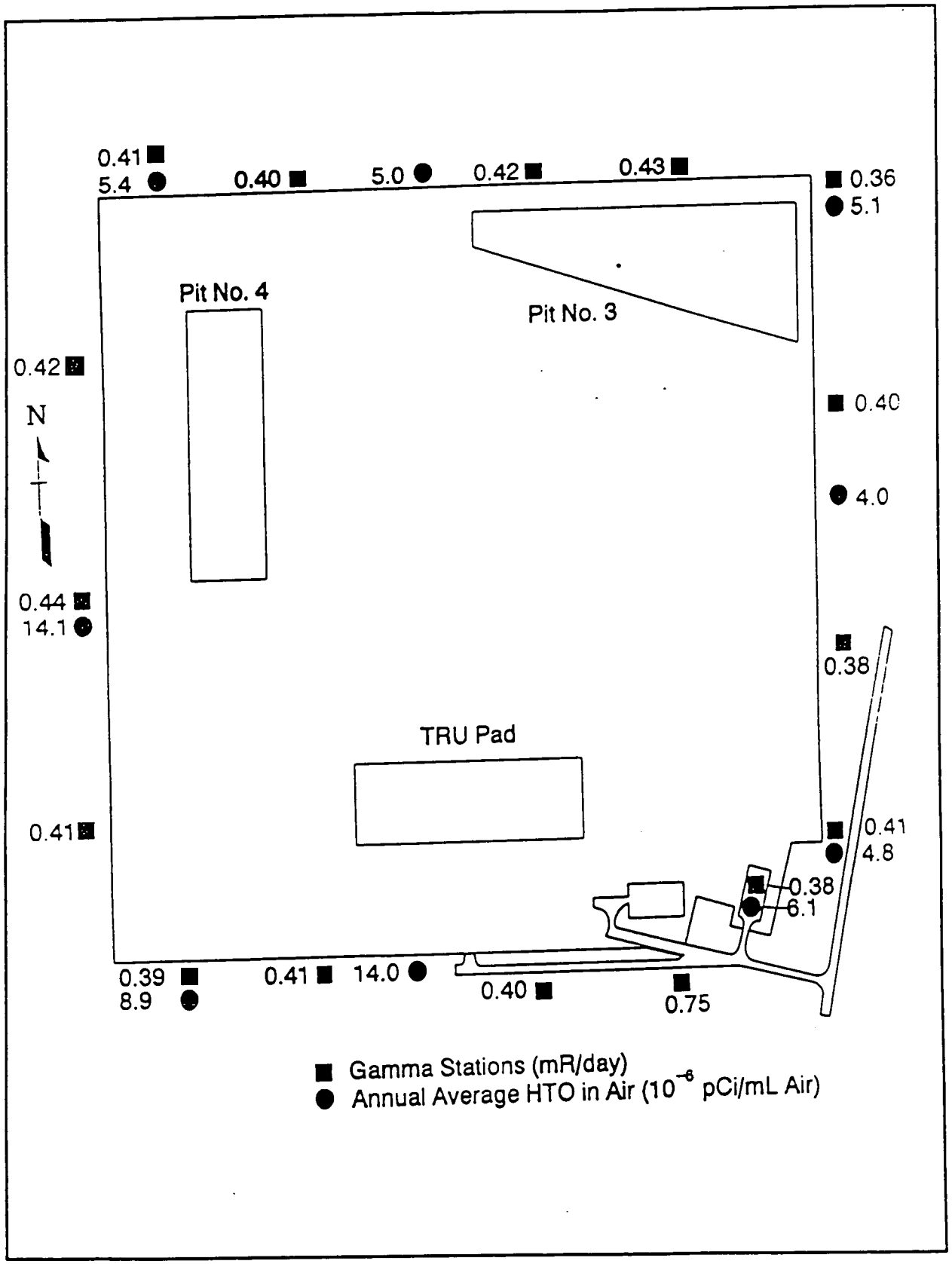

Figure 5.3 RWMS Tritiated Water Vapor Annual Average Results - 1991

samples were taken from each pond and, where possible, from the influent. Radioactive liquid effluents discharged to onsite ponds contained approximately 1800 curies of ^{3}H during 1991. Radioactivity in liquid discharges released to onsite waste treatment or disposal systems (containment ponds) was monitored to assess the efficacy of treatment and control and provide a quantitative and qualitative annual summary of the radioactivity released onsite.

5.1.3.1 TUNNELS

Rainier Mesa in Area 12 is the location for nuclear tests that are conducted within tunnels by the DOD. As a result of drilling operations and seepage, water discharged from these tunnels was collected in containment ponds. This water was usually contaminated with radionuclides, mainly ^{3}H, generated during nuclear tests.

Liquid effluents were discharged during 1991 from three tunnels: N, T, and E. A monthly grab sample was taken from each containment pond and from the tunnel discharge. Monitoring results indicated that the water discharged from these tunnels contained measurable quantities of ^{3}H and fission products. Total quantities of ^{3}H, ^{238}Pu, $^{239+240}Pu$, and beta activity were determined for each liquid effluent source and are listed in Table 5.1.

The primary source of liquid discharges was from tunnel seepage. Onsite discharges to evaporating ponds contained approximately 1700 curies of ^{3}H. No liquid effluents were discharged offsite. An additional 120 curies was released to the Area 5 radionuclide migration study ditch, see Section 5.1.3.2 below, for a total NTS release of approximately 1800 curies of ^{3}H to onsite ponds. Discharges of other radionuclides totaled less than 20 mCi.

During 1991 an estimated 1.8×10^{8} liters of water were discharged into the T Tunnel containment ponds. Sampling results from the tunnel effluent pipe indicated an annual average of 9.2×10^{3} pCi/mL (3.4×10^{5} Bq/L) of ^{3}H. Therefore, the total quantity of ^{3}H discharged out of the T Tunnel complex was calculated to be 1700 curies. Additional ^{3}H effluent data for T Tunnel and other sites discussed in Section 5.1.3 are found in Table 5.3.

At N Tunnel an estimated 6.4×10^{7} liters of water were discharged into the containment ponds. The average 1991 annual concentration of ^{3}H from samples taken at the N Tunnel effluent pipe was 290 pCi/mL (1.1×10^{4} Bq/L). The gamma emitters were for the most part undetected. The total ^{3}H discharge from N Tunnel activities for 1991 was calculated to be 19 curies.

The E Tunnel complex has been inoperative for several years. However, water continued to discharge from the tunnel. The total flow during 1991 was estimated to be 2.3×10^{7} liters. Samples taken from this liquid discharge contained an annual average of 2.2×10^{3} pCi/mL (8.1×10^{4} Bq/L) of ^{3}H. The containment ponds for this tunnel were dry during 1991. The total ^{3}H activity discharged into the environment from E Tunnel effluents was calculated to be 50 curies.

5.1.3.2 RADIONUCLIDE MIGRATION STUDY

Pumping of the radionuclide migration study well in Area 5 continued, with occasional interruptions, through August 1991, when it was permanently shut down. This well (U5eRNM2S), located 91 meters (297 feet) from the CAMBRIC underground nuclear test location, has been pumped almost continuously since 1975 to induce migration of radionuclides from the CAMBRIC cavity to the well through the subsurface in order to study

migration potential and rates. The CAMBRIC test was conducted 73 meters (241 feet) below the water table in 1965. Water pumped to the surface was released to a man-made ditch, which drained to the edge of the Frenchman Flat playa, forming a small pond area. Tritium had been observed in the pumped water since 1978 (Burbey and Wheatcraft 1986). The well did not operate from December 18, 1990 to February 4, 1991, from May 3 to May 13, and from July 2 to July 8. It was shut down permanently at the end of August 1991.

The concentration of ^{3}H in the water discharged from the well averaged 300 pCi/mL (1.1×10^{4} Bq/L) during 1991. The flow from this well, measured 2,270 liters per minute (600 gallons per minute) and discharged a total volume of 4.0×10^{8} liters during 1991 for a total ^{3}H discharge into the NTS environment of 120 curies. The water was not used for drinking or industrial purposes.

5.1.3.3 DECONTAMINATION FACILITY

The Decontamination Facility, located in Area 6, generated contaminated water during equipment decontamination processes which was discharged into a containment pond. Grab samples were taken from this pond on a monthly basis and analyzed for ^{3}H, beta, ^{238}Pu, $^{239+240}Pu$, and gamma activity.

Table 5.3 Tritium in NTS Effluents - 1991

Location	Discharge Volume (L)	Average ^{3}H Concentration (pCi/mL)	Total ^{3}H Discharge (Ci)[a]
T Tunnel	1.8×10^{8}	9.2×10^{3}	1700
N Tunnel	6.4×10^{7}	2.9×10^{2}	19
E Tunnel	2.3×10^{7}	2.2×10^{3}	50
U5eRNM2S	4.0×10^{8}	3.0×10^{2}	120
Area 6 Decontamination Facility Pond	3.0×10^{6}	6.0×10^{0}	1.8×10^{-2}

(a) Multiply by 3.7×10^{10} to obtain Bq.

During 1991 sampling results from influent to the containment pond at the Decontamination Facility were consistently below detection limits and DOE Order 5400.5 DCGs for all radionuclides except ^{3}H, as discussed under "Containment Ponds" in Section 5.2.1.5. The annual average of ^{3}H at the Decontamination Facility containment pond was 6 pCi/mL (2.2×10^{2} Bq/L). The total volume of liquid discharged to the containment pond during 1991 was estimated to be 3×10^{6} liters. Therefore, the total discharge of ^{3}H for 1991 was estimated to be 1.8×10^{-2} curies.

5.2 RADIOLOGICAL ENVIRONMENTAL SURVEILLANCE

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Onsite surveillance of airborne particulates, noble gases, and tritiated water vapor indicated onsite concentrations that were generally not statistically different from background concentrations. Surface water samples collected from open reservoirs or natural springs and industrial-purpose water gave no indication of statistically significant contamination levels. Groundwater monitoring results also showed no levels different from background. External gamma exposure monitoring indicated that the gamma environment within the NTS remained consistent with previous years. All gamma monitoring stations displayed expected results, ranging from the background levels predominant throughout the NTS to the types of exposure rates associated with known contaminated zones and radiological material storage facilities. Special environmental studies included soil radionuclide transport studies and development of a NTS-specific dose assessment model. Results of offsite environmental surveillance by the EMSL-LV indicated no NTS-related radioactivity was detected at any air sampling station, and there were no apparent net exposures detectable by the offsite dosimetry network. Test-related radionuclides were detected in tissues from animals collected onsite and, possibly in some non-leafy vegetables collected offsite.

5.2.1 ONSITE ENVIRONMENTAL SURVEILLANCE

Onsite radiological surveillance consists of a network of 52 air sampling stations; 7 radioactive noble gas sampling stations; 17 tritiated water vapor sampling stations; surface water samples from 15 open water supply reservoirs, 7 springs, 9 wastewater containment ponds, and 3 sewage lagoons; groundwater samples from 9 potable supply wells, 4 non-potable supply wells and 9 drinking water consumption points; and 187 ambient gamma exposure measurements taken with TLDs. Additional radiological studies were conducted through the Basic Environmental Compliance and Monitoring Program (BECAMP), including investigating the movement of radionuclides on and around the NTS through horizontal movement, water-driven erosion, vertical migration, and wind-driven erosional resuspension; development of a human dose-assessment model specific to the environmental and radiological conditions of the NTS; preparation of a peer-reviewed publication that addresses an important issue related to the potential environmental impacts of past, present, and future activities on the NTS; and monitoring the populations of flora and fauna on the NTS to assess changes over time in the ecological condition of the NTS (see Section 7 of this volume).

5.2.1.1 RADIOACTIVITY IN AIR

Fifty-two air sampling stations were operated continuously. At each of the stations, samples were collected weekly on glass fiber filters (for particulate) and charcoal cartridges (for

halogens). The filters were counted for gross beta and gamma activity each week, combined at the end of the month, and then analyzed for ^{238}Pu and $^{239+240}Pu$. The charcoal cartridge was counted for gamma activity each week. The individual gross beta, ^{238}Pu, $^{239+240}Pu$, and gamma sampling results are listed in Volume II, Appendix A, "Onsite ^{238}Pu, $^{239+240}Pu$, Gross Beta, and Gamma-Emitting Radionuclides in Air," Attachments A.1 through A.4.

Air monitoring for the noble gases ^{85}Kr and ^{133}Xe was performed at seven fixed locations. These air samples were also collected weekly. A distillation process separated the components of the air, and the radioactive krypton and xenon in the sample were measured. Tritiated water vapor was monitored continuously at 17 locations. Samples were collected every two weeks and analyzed for ^{3}H.

For the purpose of comparing measured quantities of airborne radioactivity to the Derived Air Concentrations (DAC's, the guides for occupational exposures) found in DOE Order 5480.11 and to the Derived Concentration Guide (DCG, the guide for exposures to members of the general public) found in DOE Order 5400.5, the following assumptions were made:

- The chemical species of the radionuclides detected was unknown, so the most restrictive DAC or DCG was used (almost always Class Y compounds, which take on the order of years to clear from the respiratory system). All of the DCGs and DACs used are listed in Table 5.4.

- For air sampling results, all of the gross beta activity detected was assumed to be ^{90}Sr.

5.2.1.2 PARTICULATE SAMPLING RESULTS

GROSS BETA

Figure 5.4 displays the average NTS gross beta results for 1991 sampling. Sampling results from the RWMS in Area 5 are shown in Figures 5.2 and 5.3. Air particulate samples were held for seven days prior to gross beta counting and gamma spectrum analysis to allow for the decay of radon and radon daughters. Samples collected at Gate 200 in Area 5 were not held for decay of radon daughters prior to gross beta analysis. The results from this station provided a useful indication of any Site-wide anomalous concentrations. The statistical evaluation of this analysis is presented in Appendix A in Volume II. Table 5.5 presents the network arithmetic averages, minimums, and maximums for 1991 airborne gross beta sampling results.

The network (all locations excluding Gate 200) annual average gross beta concentration was 1.9×10^{-14} µCi/mL (7.0×10^{-4} Bq/m^3). This concentration is 0.001 percent of the ^{90}Sr DAC listed in DOE Order 5480.11 and 2.1 percent of the DCG noted in DOE Order 5400.5 adjusted to an annual EDE of 10 mrem. One standard deviation of this annual average was 6.4×10^{-15} µCi/mL (2.4×10^{-4} Bq/m^3). The statistical evaluation of the gross beta concentrations indicated that a lognormal distribution provides an adequate approximation to the true distribution. The network annual geometric mean and geometric standard deviation of the data were 1.8×10^{-14} µCi/mL and 1.4 (6.7×10^{-4} Bq/m^3 and 1.4). All results were above the MDC.

Table 5.4 Derived Limits for Radionuclides in Air and Water

	µCi/mL		
Radionuclide	DAC (air)[(a)]	DCG (air)[(b)]	DCG (water)[(c)]
^{3}H	2×10^{-5}	1×10^{-8}	9×10^{-5}
^{40}K	2×10^{-7}	9×10^{-11}	3×10^{-7}
^{85}Kr (ns)	1×10^{-4}	3×10^{-7}	-
^{90}Sr	2×10^{-9}	9×10^{-13}	3×10^{-8}
^{133}Xe	1×10^{-4}	5×10^{-8}	-
^{226}Ra	3×10^{-10}	1×10^{-13}	5×10^{-9}
^{238}Pu	7×10^{-12}	3×10^{-15}	9×10^{-9}
$^{239+240}Pu$	6×10^{-12}	2×10^{-15}	6×10^{-9}

(ns) = nonstochastic value

(a) DAC - The Derived Air Concentration used for limiting radiation exposures through inhalation of radionuclides by workers. The values are based on either a stochastic (committed effective dose equivalent) dose of 5 rem or a nonstochastic (ns) organ dose of 50 rem, whichever is more limiting.

(b) DCG - Derived Concentration Guides are reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. The DCG values are based on an effective dose equivalent of 10 mrem for a year as required by 40CFR61.92.

(c) The values listed for beta and photon emitters in the table are based on 4 mrem committed effective dose equivalent for the radionuclide taken into the body by ingestion of water during one year using ICRP-30 ALIs.

PLUTONIUM

Monthly composite samples from each particulate sampling location were analyzed for ^{238}Pu and $^{239+240}Pu$. Sampling results averaged below 10^{-15} µCi/mL (10^{-4} Bq/m^3) of $^{239+240}Pu$ and 10^{-17} µCi/mL (10^{-6} Bq/m^3) of ^{238}Pu for all locations during 1991, with the majority of results for both isotopes being on the order of 10^{-18} µCi/mL (10^{-5} Bq/m^3). Figure 5.5 shows the airborne $^{239+240}Pu$ annual average results at the sampling locations. Tables 5.6 and 5.7 list the measured minimum, maximum, and average $^{239+240}Pu$ and ^{238}Pu concentrations for the year, respectively. A negative result indicates that the sample count was less than the background count.

The maximum annual average $^{239+240}Pu$ concentration was found at the Area 3, U3ah/at North sampling location. Results from the samples taken at the Area 3 facility averaged 1.7×10^{-16} µCi/mL (6.3×10^{-6} Bq/m^3) during 1991. This quantity was 0.003 percent of the DAC and 9 percent of the DCG adjusted to an annual EDE of 10 mrem. Analysis of the $^{239+240}Pu$ results

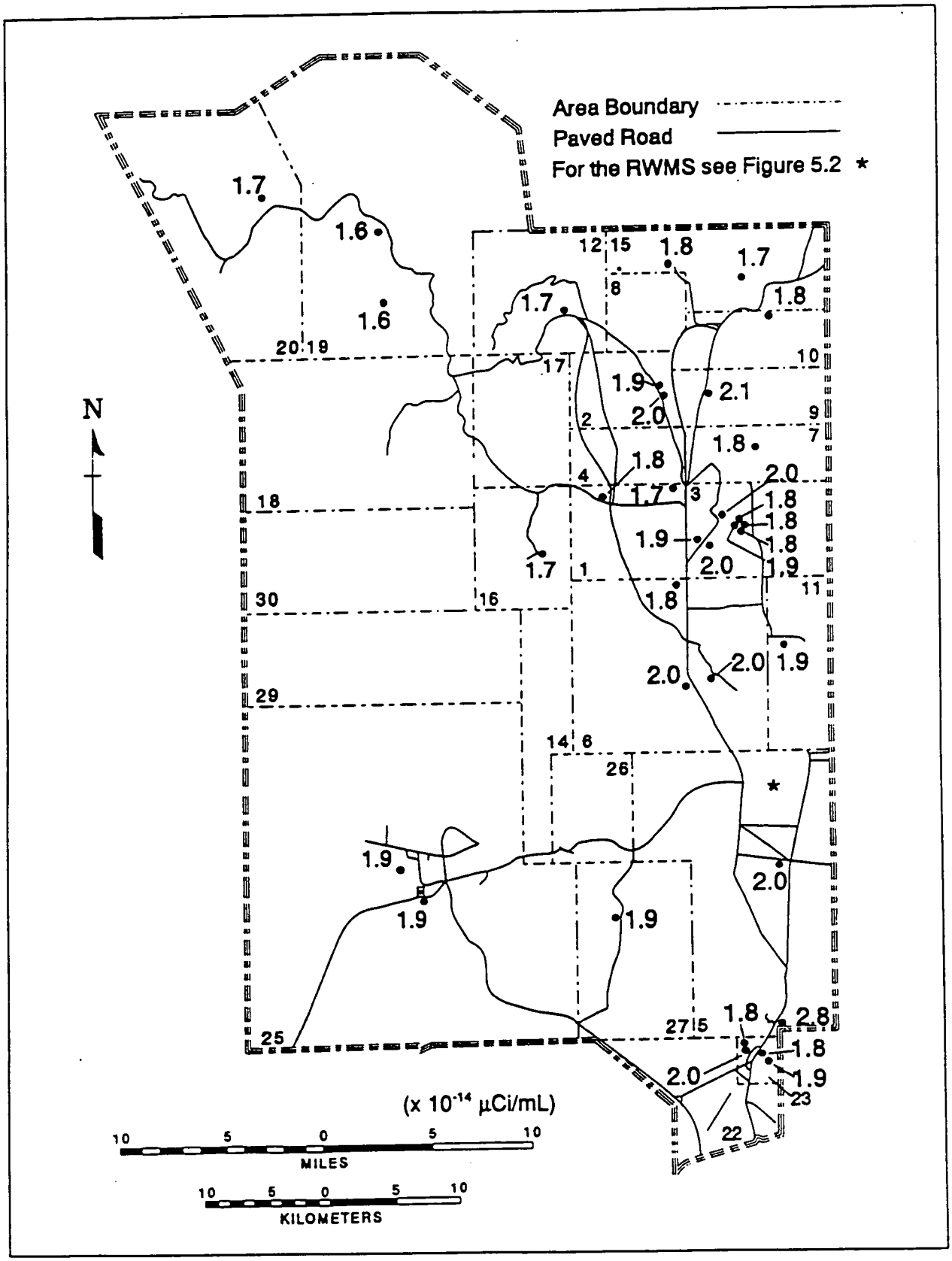

Figure 5.4 NTS Airborne Gross Beta Annual Average Concentrations - 1991

Table 5.5 Airborne Gross Beta Concentrations on the NTS - 1991

Gross Beta Concentration x 10^{-14} µCi/mL

Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 01, BJY	49	1.74	0.552	0.0789	0.850	3.40
Area 01, Gravel Pit	48	1.78	0.563	0.0813	0.910	3.40
Area 02, 2-1 Substation	50	2.02	1.54	0.218	0.830	12.0
Area 02, Complex	49	1.86	0.519	0.0741	1.10	3.40
Area 03, 3-300 Bunker	50	1.97	0.608	0.0860	0.860	3.50
Area 03, Complex	48	1.95	0.580	0.0837	0.960	3.50
Area 03, Complex No. 2	50	1.98	0.712	0.101	0.100	3.70
Area 03, U3ah/at East	49	1.85	0.581	0.0830	0.690	3.20
Area 03, U3ah/at North	50	1.85	0.596	0.0843	0.600	3.50
Area 03, U3ah/at South	50	1.84	0.559	0.0790	0.900	3.30
Area 03, U3ah/at West	50	1.90	0.640	0.0905	0.620	3.40
Area 05, DOD Yard	50	1.68	0.697	0.0986	0.540	3.80
Area 05, Gate 200	50	2.81	1.73	0.244	0.840	9.10
Area 05, RWMS No. 1	52	2.06	0.699	0.0970	0.970	4.00
Area 05, RWMS No. 2	50	1.99	0.657	0.0929	0.990	4.00
Area 05, RWMS No. 3	52	2.05	0.753	0.104	0.860	5.00
Area 05, RWMS No. 4	52	2.04	0.673	0.0933	0.970	3.70
Area 05, RWMS No. 5	52	1.94	0.698	0.0968	0.390	3.60
Area 05, RWMS No. 6	52	1.99	0.653	0.0906	0.900	3.40
Area 05, RWMS No. 7	52	2.00	0.718	0.0996	0.860	4.60
Area 05, RWMS No. 8	51	2.02	0.682	0.0955	0.990	3.70
Area 05, RWMS No. 9	52	1.95	0.649	0.0900	1.000	3.70
Area 05, RWMS Pit No. 3	49	1.98	0.660	0.0942	0.860	3.60
Area 05, RWMS Pit No. 4	52	1.97	0.682	0.0946	0.940	3.60
Area 05, RWMS TP North	52	1.97	0.717	0.0994	0.830	3.90
Area 05, RWMS TP Northeast	52	2.13	0.711	0.0985	1.000	3.90
Area 05, RWMS TP Northwest	52	2.00	0.674	0.0935	0.970	3.70
Area 05, RWMS TP South	51	1.97	0.711	0.0995	0.580	3.80
Area 05, RWMS TP Southeast	51	1.92	0.734	0.103	0.930	5.00
Area 05, RWMS TP Southwest	52	2.01	0.669	0.0928	0.880	3.70
Area 05, Well 5B	48	1.96	0.675	0.0975	0.910	3.70
Area 06, CP-6	52	2.04	0.597	0.0827	0.980	3.60
Area 06, Well 3 Complex	50	1.85	0.614	0.0868	0.550	3.60
Area 06, Yucca Complex	52	2.02	0.564	0.0783	0.950	3.30
Area 07, Ue7ns	47	1.79	0.553	0.0806	0.770	3.40
Area 09, 9-300 Bunker	48	2.13	0.695	0.100	0.820	4.00
Area 10, Gate 700 South	50	1.82	0.550	0.0778	0.870	3.30
Area 11, Gate 293	52	1.89	0.592	0.0821	0.890	3.20
Area 12, Complex	49	1.68	0.758	0.108	0.320	4.50
Area 15, EPA Farm	50	1.85	0.573	0.0811	0.850	3.40
Area 15, PILEDRIVER	12	1.67	0.631	0.182	0.960	3.00
Area 16, 3545 Substation	48	1.72	0.509	0.0734	0.760	3.20
Area 19, Echo Peak	46	1.59	0.508	0.0749	0.560	3.00
Area 19, Pahute Substation	49	1.62	0.488	0.0697	0.810	3.10
Area 20, Dispensary	49	1.70	0.484	0.0692	0.820	3.20
Area 23, Building 790	52	2.06	0.664	0.0921	0.830	3.90
Area 23, Building 790 No. 2	52	1.86	0.648	0.0899	0.850	3.60
Area 23, East Boundary	52	1.92	0.892	0.124	0.430	6.30
Area 23, H&S Building Roof	51	1.83	0.612	0.0857	0.770	3.60
Area 25, E-MAD North	49	1.93	0.691	0.0987	0.930	4.00
Area 25, NRDS Warehouse	51	1.88	0.553	0.0774	0.870	3.50
Area 27, Cafeteria	52	1.93	0.627	0.0870	0.920	3.70

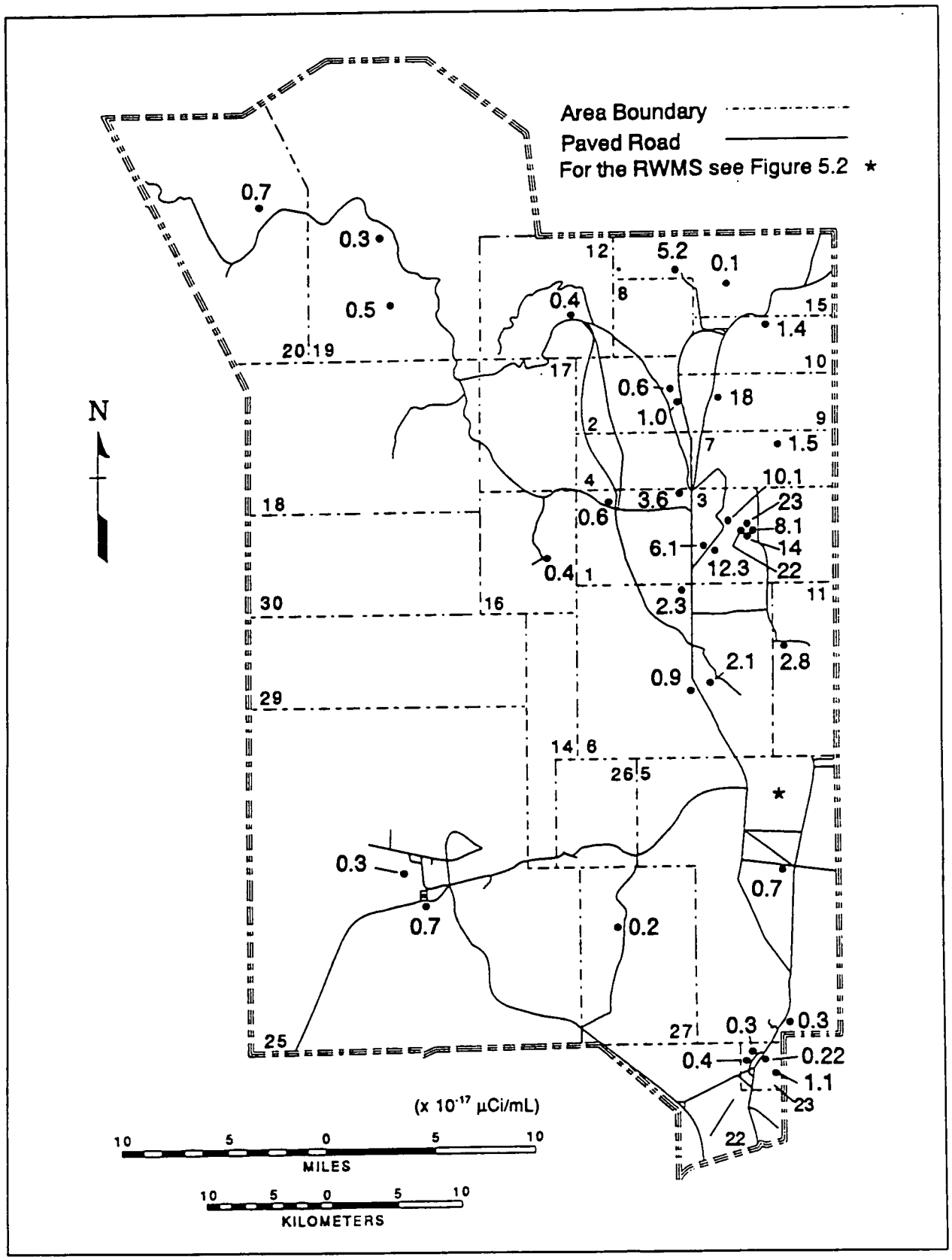

Figure 5.5 NTS Airborne $^{239+240}$Pu Annual Average Results - 1991

Table 5.6 Airborne $^{239+240}Pu$ Concentrations on the NTS - 1991

	$^{239+240}Pu$ Concentration x 10^{-17} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 01, BJY	12	3.57	2.42	0.699	0.250	11.3
Area 01, Gravel Pit	12	0.609	0.494	0.143	-0.0840	1.61
Area 02, 2-1 Substation	12	0.965	0.860	0.248	-0.0430	2.71
Area 02, Complex	12	0.602	0.625	0.180	-0.0500	2.05
Area 03, 3-300 Bunker	12	12.3	8.42	2.43	2.36	29.8
Area 03, Complex	12	6.06	6.22	1.80	0.00	20.8
Area 03, Complex No. 2	12	10.1	11.4	3.29	3.68	39.5
Area 03, U3ah/at East	12	8.09	6.07	1.75	1.56	21.4
Area 03, U3ah/at North	12	22.9	21.1	6.08	3.88	73.2
Area 03, U3ah/at South	12	13.5	10.1	2.90	4.10	31.5
Area 03, U3ah/at West	12	22.5	15.7	4.53	7.51	52.0
Area 05, DOD Yard	12	1.55	3.82	1.10	0.030	13.6
Area 05, Gate 200	12	0.346	0.715	0.206	-0.0740	2.49
Area 05, RWMS No. 1	12	0.541	0.455	0.131	0.0340	1.57
Area 05, RWMS No. 2	12	0.526	0.594	0.172	0.0500	1.77
Area 05, RWMS No. 3	12	1.16	2.12	0.612	0.0360	7.76
Area 05, RWMS No. 4	12	0.483	0.496	0.143	0.0900	1.84
Area 05, RWMS No. 5	12	1.55	3.97	1.15	0.0200	14.1
Area 05, RWMS No. 6	12	0.218	0.189	0.0545	0.0791	0.641
Area 05, RWMS No. 7	12	0.653	0.615	0.178	0.0480	2.03
Area 05, RWMS No. 8	12	0.654	0.919	0.265	-0.0720	3.44
Area 05, RWMS No. 9	12	0.629	0.717	0.207	0.194	2.83
Area 05, RWMS Pit No. 3	12	0.395	0.452	0.131	-0.0740	1.05
Area 05, RWMS Pit No. 4	12	0.720	0.659	0.190	0.139	2.41
Area 05, RWMS TP North	12	0.438	0.477	0.138	-0.0750	1.41
Area 05, RWMS TP Northeast	12	0.721	0.673	0.194	-0.0760	1.98
Area 05, RWMS TP Northwest	12	0.450	0.400	0.116	0.0440	1.22
Area 05, RWMS TP South	12	0.486	0.440	0.127	-0.0750	1.46
Area 05, RWMS TP Southeast	12	1.28	1.54	0.445	0.239	5.39
Area 05, RWMS TP Southwest	12	0.400	0.257	0.0742	0.0466	0.902
Area 05, Well 5B	12	0.688	0.673	0.194	-0.0740	2.32
Area 06, CP-6	12	0.928	0.828	0.239	-0.0800	2.58
Area 06, Well 3 Complex	12	2.27	3.76	1.08	-0.0400	13.5
Area 06, Yucca Complex	12	2.07	1.49	0.429	-0.0120	5.62
Area 07, Ue7ns	12	1.50	0.897	0.259	0.142	3.24
Area 09, 9-300 Bunker	12	17.9	9.35	2.70	4.26	35.0
Area 10, Gate 700 South	12	1.37	1.37	0.394	0.264	5.37
Area 11, Gate 293	12	2.82	6.37	1.84	-0.030	22.4
Area 12, Complex	12	0.381	0.510	0.147	-0.0720	1.43
Area 15, EPA Farm	12	5.24	6.87	1.98	0.210	24.5
Area 15, PILEDRIVER	3	0.111	0.0447	0.0258	0.0656	0.155
Area 16, 3545 Substation	12	0.434	0.798	0.230	-0.0470	2.89
Area 19, Echo Peak	11	0.471	0.723	0.218	-0.0720	2.21
Area 19, Pahute Substation	11	0.308	0.262	0.0791	0.0692	0.881
Area 20, Dispensary	12	0.725	1.48	0.426	0.0220	5.34
Area 23, Building 790	12	0.340	0.248	0.0715	0.0350	0.673
Area 23, Building 790 No. 2	12	0.384	0.497	0.143	-0.0780	1.41
Area 23, East Boundary	12	1.09	2.12	0.611	-0.0730	7.28
Area 23, H&S Building Roof	12	0.225	0.245	0.0709	0.0347	0.902
Area 25, E-MAD North	12	0.320	0.269	0.0775	0.0413	0.916
Area 25, NRDS Warehouse	12	0.682	1.17	0.338	-0.0760	4.23
Area 27, Cafeteria	12	0.208	0.275	0.0792	0.0433	0.773

Table 5.7 Airborne ^{238}Pu Concentrations on the NTS - 1991

Location	^{238}Pu Concentration x 10^{-18} µCi/mL					
	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 01, BJY	11	-1.44	12.6	3.80	-26.6	17.6
Area 01, Gravel Pit	10	-0.990	7.13	2.25	-14.1	8.97
Area 02, 2-1 Substation	12	-0.780	7.98	2.30	-18.6	9.33
Area 02, Complex	11	-0.600	8.34	2.51	-9.98	16.7
Area 03, 3-300 Bunker	12	1.05	8.98	2.59	-8.91	21.5
Area 03, Complex	11	-2.54	7.09	2.14	-13.4	12.5
Area 03, Complex No. 2	12	0.200	10.5	3.02	-17.0	16.1
Area 03, U3ah/at East	12	3.83	7.14	2.06	-8.99	15.8
Area 03, U3ah/at North	11	-0.380	12.5	3.76	-27.2	12.8
Area 03, U3ah/at South	12	-0.540	3.50	1.01	-6.41	6.43
Area 03, U3ah/at West	12	4.97	10.2	2.93	-11.3	20.0
Area 05, DOD Yard	12	2.14	5.83	1.68	-6.18	12.0
Area 05, Gate 200	12	3.21	6.19	1.79	-9.34	10.5
Area 05, RWMS No. 1	12	2.37	8.33	2.40	-11.4	16.0
Area 05, RWMS No. 2	11	-1.63	9.61	2.90	-12.4	19.0
Area 05, RWMS No. 3	12	2.27	4.27	1.23	-5.96	8.56
Area 05, RWMS No. 4	12	2.25	8.68	2.51	-13.4	17.7
Area 05, RWMS No. 5	12	-2.26	6.29	1.82	-13.6	7.05
Area 05, RWMS No. 6	12	-1.11	6.04	1.74	-11.7	7.81
Area 05, RWMS No. 7	12	0.640	6.66	1.92	-9.87	14.4
Area 05, RWMS No. 8	11	2.29	6.52	1.97	-6.79	12.0
Area 05, RWMS No. 9	12	-0.730	3.90	1.13	-9.65	4.79
Area 05, RWMS Pit No. 3	12	0.940	8.55	2.47	-13.50	13.6
Area 05, RWMS Pit No. 4	12	1.18	8.60	2.48	-20.2	10.6
Area 05, RWMS TP North	12	1.44	4.71	1.36	-4.86	13.2
Area 05, RWMS TP Northeast	11	-0.800	5.85	1.76	-10.4	6.74
Area 05, RWMS TP Northwest	12	3.29	6.24	1.80	-7.91	11.6
Area 05, RWMS TP South	12	-1.40	6.46	1.87	-10.8	9.22
Area 05, RWMS TP Southeast	12	-0.390	5.73	1.66	-13.3	7.20
Area 05, RWMS TP Southwest	12	0.430	6.37	1.84	-7.89	12.1
Area 05, Well 5B	11	1.85	6.06	1.83	-8.42	10.3
Area 06, CP-6	10	0.300	5.61	1.78	-11.2	5.90
Area 06, Well 3 Complex	10	0.530	7.08	2.24	-9.08	12.7
Area 06, Yucca Complex	11	-2.50	4.55	1.37	-11.8	4.72
Area 07, Ue7ns	12	-0.100	7.39	2.13	-13.8	14.6
Area 09, 9-300 Bunker	11	5.20	8.42	2.54	-3.60	24.3
Area 10, Gate 700 South	10	4.32	6.47	2.05	-3.01	15.3
Area 11, Gate 293	11	0.920	7.88	2.38	-8.50	14.4
Area 12, Complex	10	-0.600	4.50	1.42	-8.08	4.50
Area 15, EPA Farm	11	1.54	5.22	1.57	-6.50	10.4
Area 15, PILEDRIVER	3	10.2	1.49	0.859	8.51	11.3
Area 16, 3545 Substation	11	-0.700	7.94	2.39	-11.4	11.7
Area 19, Echo Peak	9	2.09	8.45	2.82	-8.57	19.6
Area 19, Pahute Substation	10	1.62	7.66	2.42	-11.1	15.8
Area 20, Dispensary	12	1.48	8.08	2.33	-11.9	14.1
Area 23, Building 790	12	0.230	7.01	2.02	-10.4	10.7
Area 23, Building 790 No. 2	9	0.750	7.80	2.60	-9.46	14.2
Area 23, East Boundary	12	0.040	6.76	1.95	-12.2	13.6
Area 23, H&S Building Roof	11	-1.17	8.46	2.55	-17.1	11.6
Area 25, E-MAD North	12	1.49	7.19	2.08	-8.72	15.4
Area 25, NRDS Warehouse	11	1.42	6.61	1.99	-7.42	13.5
Area 27, Cafeteria	10	1.92	5.60	1.77	-8.44	8.04

indicated greater concentrations of this radionuclide in Areas 3 and 9 and lower concentrations in other areas This is not unexpected, since historically this has been the case. Further discussion can be found in the statistical analysis in Appendix A in Volume II. The arithmetic mean and standard deviation of ^{238}Pu in air for all stations were 0.77×10^{-18} and 97.3×10^{-18} µCi/mL, respectively. Because the majority of measured values were negative after background subtraction, the geometric mean and standard deviation were not calculated. The 1×10^{-17} µCi/mL at PILEDRIVER was based on only three samples. In prior years the mean level at this location was near background. The data and the statistical analysis are presented in Appendix A in Volume II.

The presence of plutonium on the NTS is primarily due to atmospheric tests and tests in which nuclear devices were detonated with high explosives (called "safety shots"). These latter tests spread low-fired plutonium in the eastern and northeastern areas of the NTS (see Chapter 2, Figure 2.3 for these locations). Two decades later, higher than normal levels of plutonium in the air are still detected in Areas 1, 2, 3, 7, 8, 9, 10, and 15. During waste disposal activities at the Area 3 Bulk Waste Management Facility (BWMF), some of the ^{238}Pu and $^{239+240}Pu$ becomes airborne. As such, elevated levels of plutonium have been detected around the Area 3 BWMF for several years. (The BWMF samples are designated as the Area 3, U3ah/at sampling sites in the data tables.)

Gamma

The charcoal cartridges used to collect halogen gases and the glass fiber filters used to collect particulates were analyzed by gamma spectroscopy. The results from the gamma spectroscopy analyses are provided in Appendix A, Attachment A.4. Except for four isolated cases, all isotopes detected by gamma spectroscopy were naturally occurring in the environment (^{40}K,^{7}Be, and members of the uranium and thorium series). Trace amounts of ^{183}Ta, ^{139}Ce, and ^{131}I were seen once each at different locations in Area 5, the weeks of March 4, April 1 and December 16; similarly , a trace amount of ^{144}Ce was seen at Area 11, Gate 293, the week of April 1. Those isotopes which were detected in air samples are listed in Appendix A in Volume II along with statistical discussions.

5.2.1.3 NOBLE GAS SAMPLING RESULTS

The locations at which compressed air samples were routinely collected throughout the year are shown in Figure 5.6 with the annual averages of the ^{85}Kr and ^{133}Xe analyses. All average concentrations were well below the DAC of 1×10^{-4} µCi/mL (3.7×10^{6} Bq/m^3) for each radionuclide. The samplers at the indicated locations were operated continuously throughout the year except for those at Piledriver and EPA Farm. Due to the termination of operations and electrical power at Piledriver in March 1991, the sampler was moved to the EPA Farm. Summaries of the results are listed in Tables 5.8 and 5.9. All individual results are listed in Volume II, Appendix E.

As in the past, the levels of ^{85}Kr (half-life of 10.76 years) observed in the samples were from world-wide nuclear power and fuel processing operations, with some contribution of ^{85}Kr from underground nuclear tests at the NTS. Xenon-133 is not normally detected in the environment due to its short half-life of 5.27 days, so when any is detected it is usually attributed to nuclear testing operations at the NTS.

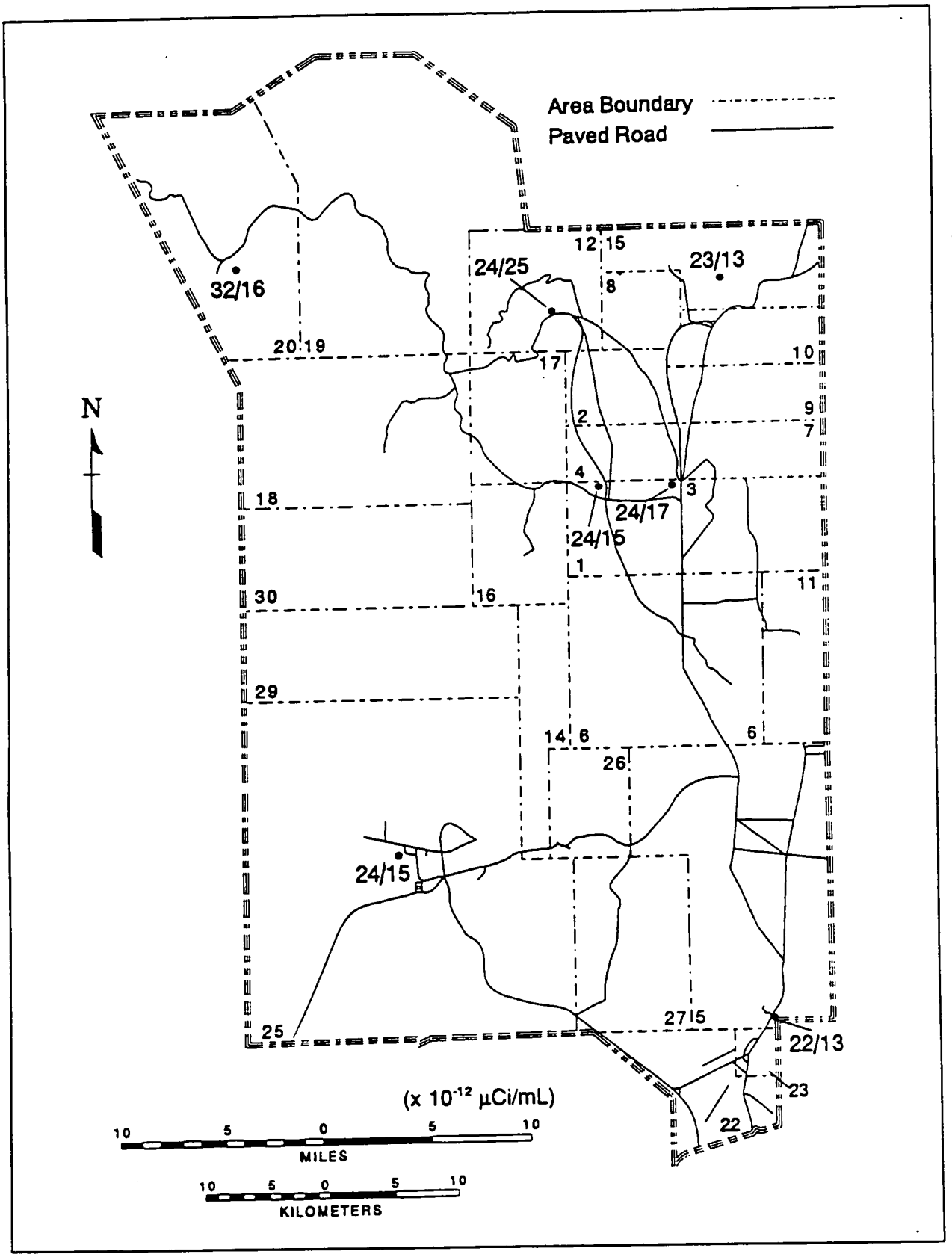

Figure 5.6 NTS $^{85}Kr/^{133}Xe$ Annual Average Concentrations - 1991

Krypton-85

A summary of all ^{85}Kr results appears in Table 5.8. An evaluation of the distribution of ^{85}Kr concentrations at each sampling location was performed to identify those values which were atypical, namely those which did not appear to be a part, statistically, of the ambient concentration of ^{85}Kr resulting from worldwide nuclear operations. From this evaluation (see Volume II, Appendix E), no ^{85}Kr values listed in Table 5.8 were found to be atypical and all values were lognormally distributed.

From the time series plots in Appendix E (Figures E.11 - E.18), no trend in concentrations was apparent. Each location had environmental levels with occasional spikes attributed to seepage of noble gases from the northern portion of the Test Site. Those samplers located in the southern portion of the Site (Gate 200 and E-MAD) had no concentration spikes and, therefore, had the smallest standard deviations.

Table 5.8 Summary of All NTS ^{85}Kr Concentrations - 1991

Location	Number of Samples	^{85}Kr Concentration x 10^{-12} µCi/mL			
		Minimum	Maximum	Average	1s
Area 1, BJY	46	14	34	24	4
Area 1, Gravel Pit	40	17	38	24	4
Area 5, Gate 200	27	14	28	22	3
Area 12, Camp	42	17	40	24	4
Area 15, EPA Farm	33	18	33	23	4
Area 15, PILEDRIVER	9	18	33	24	5
Area 15, Both Stations*	42	18	33	23	4
Area 20, Dispensary	44	17	73	32	11
Area 25, E-MAD	42	19	30	24	3
All Locations	298	14	73	25	6

* Results were combined due to proximity of stations and to statistical test that results of both Area 15 stations were not significantly different at the five percent significance level.

Again this year the highest annual average concentration of ^{85}Kr occurred at the Area 20 Dispensary, 32 x 10^{-12} µCi/mL (1.2 Bq/m^3), and the lowest occurred at the Area 5 Gate 200 station, 22 x 10^{-12} µCi/mL (8.1 x 10^{-1} Bq/m^3). This is reasonable as the sampler at the Area 20 Dispensary is in the northern portion of the NTS in the proximity of the sites where seepage of noble gases from the ground has been observed in the past, whereas Area 5, Gate 200 station is in the southern portion of the NTS away from the test areas. The statistical evaluation of these data (Volume II, Appendix E) showed that the Area 20 Dispensary average concentration was significantly higher than the other averages at the five percent significance level.

Xenon-133

The analytical results for ^{133}Xe are normally below the lower limit of detection of 24 x 10^{-12} µCi/mL (0.89 Bq/m^3) except for occasional detectable amounts due to seepage through the ground after tests (See Volume II, Appendix E, Figures E.1-E.8.) Table 5.9 summarizes the ^{133}Xe results for samples collected at each location. The highest average concentration was 25 x 10^{-12} µCi/mL (0.92 Bq/m^3) at Area 12 Camp, which is near the testing sites. The lowest annual average was 13 x 10^{-12} µCi/mL (0.48 Bq/m^3) at the Area 15 stations and Area 5, Gate 200. The lower value for Area 15, PILEDRIVER, is not considered representative since, as explained earlier, that location was sampled only for the first three months of 1991.

Table 5.9 Summary of NTS ^{133}Xe Concentrations - 1991

Location	Number of Samples	^{133}Xe Concentration x 10^{-12} µCi/mL			
		Minimum	Maximum	Average	1s
Area 01, BJY	51	-42	72	17	22
Area 01, Gravel Pit	46	-131	250	15	60
Area 05, Gate 200	50	-39	80	13	20
Area 12, Camp	47	-13	260	25	46
Area 15, EPA Farm	39	-10	71	14	15
Area 15, PILEDRIVER	9	-34	45	6.9	21
Area 15, Both Stations*	48	-34	71	13	17
Area 20, Dispensary	46	-64	330	16	55
Area 25, E-MAD	48	-66	170	15	39
All Locations	336	-131	330	16	40

* Results were combined due to proximity of stations and to statistical tests that showed that the results for both Area 15 stations were not significantly different at the five percent level.

A statistical evaluation of the ^{133}Xe data is contained in Appendix E. From this evaluation, the concentrations were found to be lognormally distributed. Most values were near the detection limit with a few high and some intermediate values occurring throughout the year. All of the detectable xenon concentrations were attributed to underground nuclear tests at the NTS. This evaluation also indicated that differences in ^{133}Xe levels were not statistically significant.

5.2.1.4 TRITIATED WATER VAPOR SAMPLING RESULTS

The concentrations of tritiated water vapor determined from sampling conducted at 17 permanent sampling stations are summarized in Table 5.10. The individual results for each sample collected during the year are listed and plotted in Volume II, Appendix B, which also includes a statistical evaluation of the data. As shown in Table 5.10, the location having the highest annual average tritium concentration was the Area 5 RWMS #7 Station with an

average of (14 ± 2) x 10^{-6} pCi/mL ([52 ± 7] x 10^{-2} Bq/m^3). This average was only 0.14 percent of the DCG for tritium adjusted for an annual EDE of 10 mrem. The annual average concentration at each station is shown on the map in Figure 5.7.

Table 5.10 Airborne Tritium Concentrations on the NTS - 1991

	^{3}H Concentration x 10^{-6} pCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation	Standard Error of the Mean	Minimum	Maximum
Area 01, BJY	23	1.75	1.95	0.407	0.070	9:13
Area 05, RWMS No. 1	25	6.13	4.62	0.923	0.510	19.9
Area 05, RWMS No. 2	24	4.82	3.45	0.704	-3.16	10.7
Area 05, RWMS No. 3	25	4.05	2.66	0.532	0.300	13.3
Area 05, RWMS No. 4	25	5.14	3.78	0.757	0.030	17.2
Area 05, RWMS No. 5	23	4.99	2.19	0.457	2.87	11.4
Area 05, RWMS No. 6	24	5.45	8.27	1.69	0.340	42.7
Area 05, RWMS No. 7	25	14.1	8.72	1.74	5.55	44.5
Area 05, RWMS No. 8	24	8.93	9.40	1.92	1.85	42.7
Area 05, RWMS No. 9	24	14.0	11.3	2.30	2.66	51.9
Area 10, Gate 700 South	23	1.47	1.90	0.395	-0.070	6.31
Area 12, Complex	24	1.27	1.78	0.364	-0.200	8.38
Area 15, EPA Farm	21	6.30	3.94	0.860	1.36	16.9
Area 23, Building 790 No. 2	23	0.900	1.10	0.206	-0.130	4.75
Area 23, East Boundary	24	0.780	1.19	0.243	-0.780	4.37
Area 23, H & S Roof	23	0.540	0.990	0.230	-0.230	3.88
Area 25, E-MAD North	25	4.49	4.93	0.987	0.150	20.5
All	405	5.1	6.6	0.33	-3.16	51.9

From the statistical evaluation, the data were found to be lognormally distributed. As shown in the time series plots of the data for each station (Volume II, Appendix B, Figures B.1-B.18), the tritium concentrations indicated no time trends, so no time series analysis was performed.

The plots do show those locations where the tritium concentrations are below or near the detection limit (about 0.5 x 10^{-6} pCi/mL) and those which are consistently above . These groupings are as follows:

Below or Near Detection Limit	Consistently Above Detection Limit
Area 01 BJY	Area 5 RWMS No. 1 - No. 9
Gate 700 South	Area 15 EPA Farm
Area 12 Complex	Area 25 E-MAD
Area 23 H&S Building Roof	
Area 23 East Boundary	
Area 23 Building 790 No. 2)	

A one-way analysis of variance to test for differences between stations means identified five overlapping groups. The lower group included the locations listed as "Below or Near

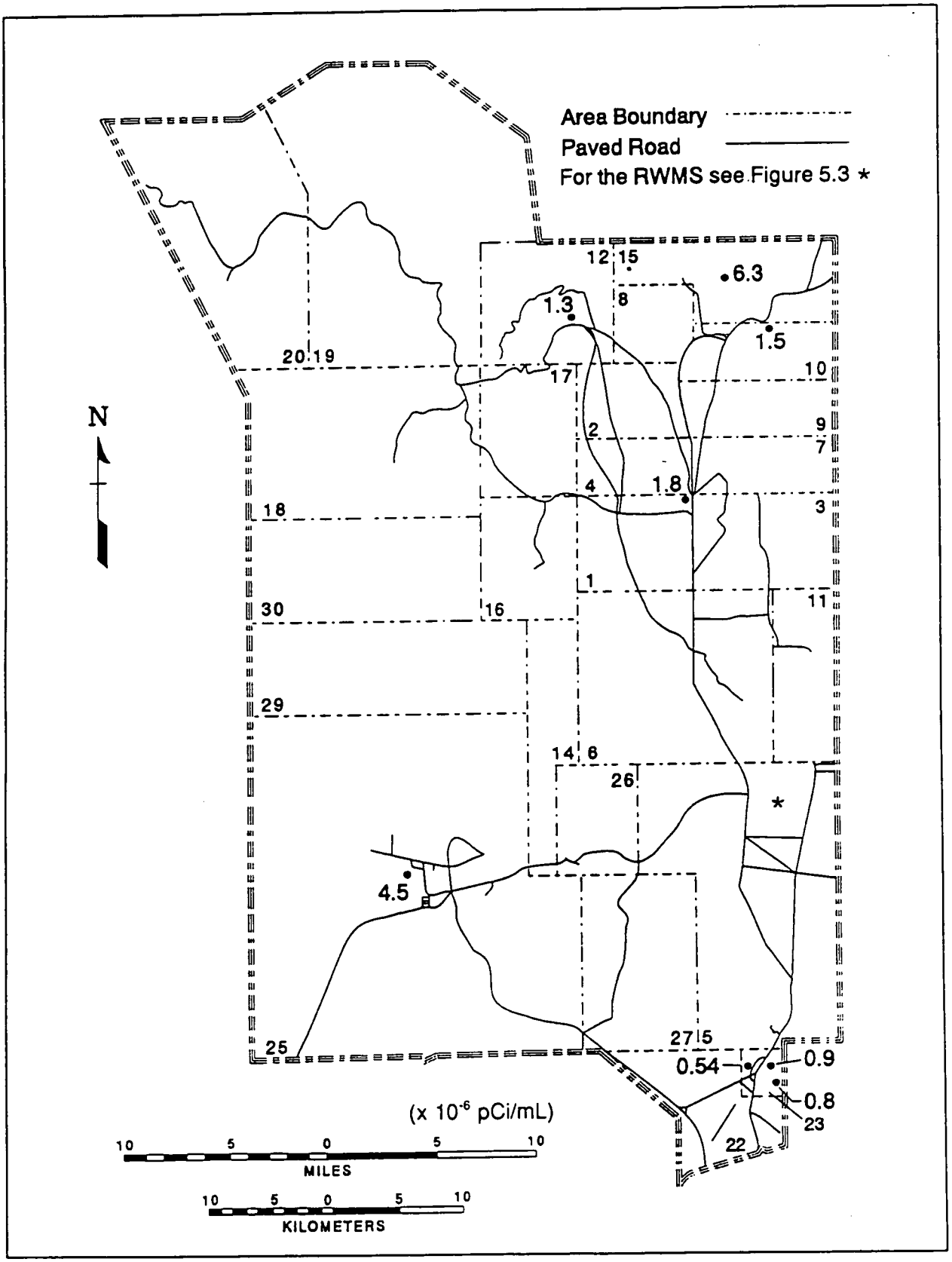

Figure 5.7 NTS Tritiated Water Vapor Annual Average Concentrations - 1991

Detection Limit" above. The tritium concentrations at these locations were generally below the detection limit except for occasional concentration spikes. The higher groupings included all the Area 5 RWMS stations, which are considered near a source of tritium, Area 25 E-MAD, and the Area 15 EPA Farm. Although this year's results appeared to fit into five groups, as opposed to three groups last year, the ranking of this year's median concentrations is similar to that of last year.

5.2.1.5 RADIOACTIVITY IN SURFACE WATER

Surface water sampling at the NTS was conducted at 15 open reservoirs, 7 natural springs, 9 containment ponds, and 3 sewage lagoons. A grab sample was taken each month from each surface water location. The sample was analyzed for ^{3}H, gross beta, and gamma activity. Each quarter an additional sample was collected and analyzed for ^{238}Pu and $^{239+240}Pu$, and in July a sample was collected for ^{90}Sr analysis. Gamma results for all sample locations indicated that radionuclide levels were consistently below the detection limit except for samples from the containment ponds. The data from the containment ponds are shown in Volume II, Appendix C, Attachments C.1 through C.7. Surface water at the NTS was scarce during 1991 because of the continuing drought. Sources of surface water were, for the most part, man-made, created for or by NTS operations. There is no known human consumption of any surface water on the NTS.

The annual average for each isotope analyzed is presented and compared to the DCG for ingested water. The one exception is the containment ponds, which are not compared to ingested water permissible concentrations. All sampling results are presented in tabular form beginning with Appendix C, Attachment C.1. In each appendix table, the result and corresponding one standard deviation (1s) counting error are presented. Any station which was determined to be statistically different from the average was noted and discussed.

With the exception of containment ponds, no single annual average of any sampling location in surface waters was found to be statistically different from any other at the five percent significance level. The analytical results from containment ponds showed measurable quantities of radioactivity and displayed identifiable trends. The following sections report statistical summary data for all surface water sampling locations.

OPEN RESERVOIRS

Open reservoirs have been established at various locations on the NTS for industrial uses. Comparisons of the annual average concentrations of radioactivity were made to the DCGs for ingested water listed in DOE Order 5400.5, even though there was no known consumption of these waters.

Gross Beta

The location of each open reservoir sampled is shown in Figure 5.8 along with its annual average gross beta concentration level. The annual average beta concentration for all open reservoirs was 8.2×10^{-9} µCi/mL (0.30 Bq/L). This beta concentration is 3 percent of the ^{40}K DCG adjusted to an annual 4 mrem EDE for ingested water. None of the reservoirs were found to be different from the annual average at the five percent significance level. Table 5.11 includes a list of the 1991 annual averages for each monitored location. Appendix C, Attachment C.5, contains the individual data results. Statistical analyses of results from open reservoir samples are presented in Appendix C.

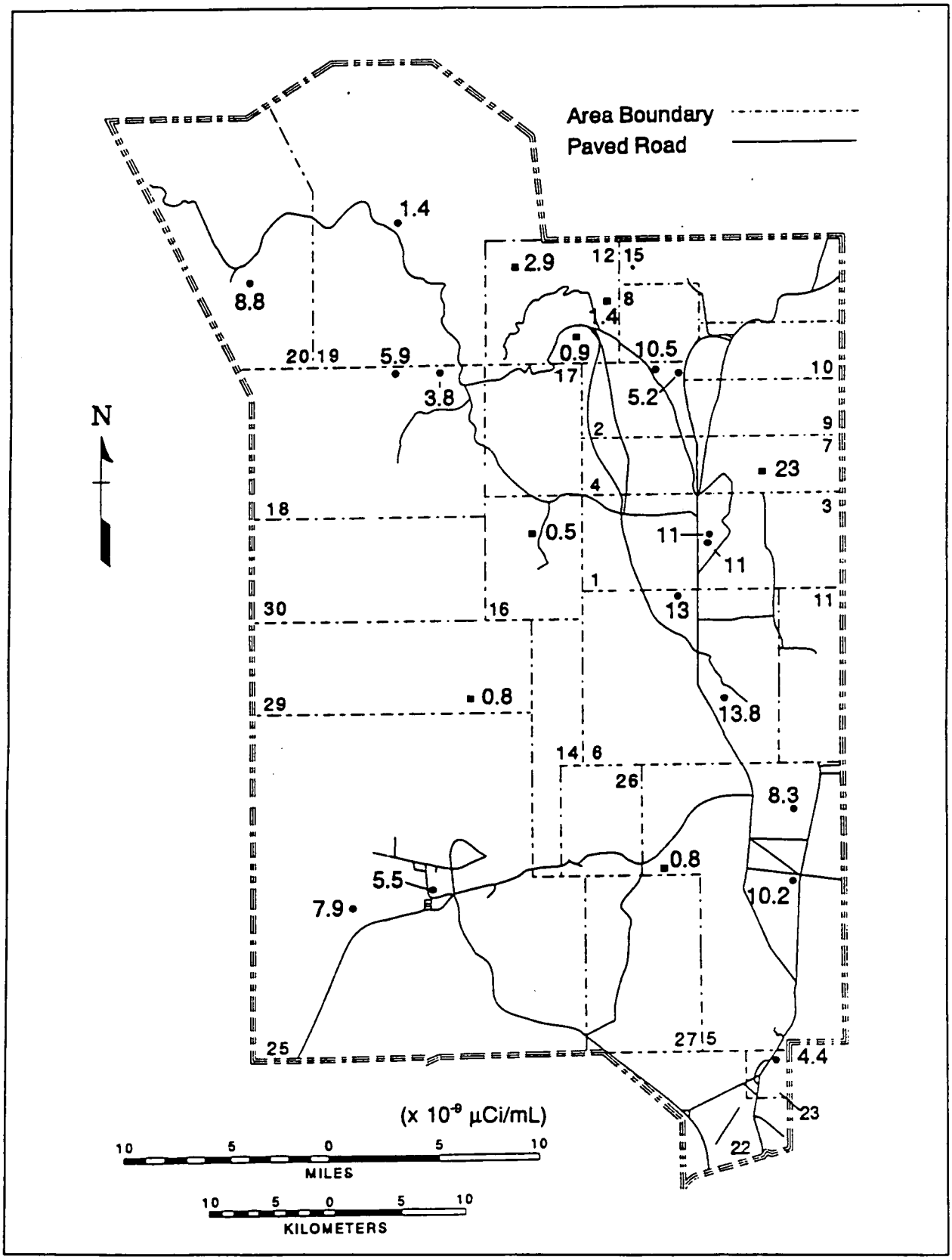

Figure 5.8 Annual Average Gross Beta in Open Reservoirs(•) and Natural Springs(■) - 1991

Table 5.11 NTS Open Reservoir Gross Beta Analysis Results - 1991

	Gross Beta Concentration x 10^{-9} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 02, Mud Plant Reservoir	12	5.23	2.02	0.583	2.80	8.80
Area 02, Well 2 Reservoir	12	10.5	2.25	0.649	8.10	15.0
Area 03, Mud Plant Reservoir	12	11.4	1.44	0.417	9.00	14.0
Area 03, Well A Reservoir	12	10.9	1.89	0.545	6.60	13.0
Area 05, Ue5c Reservoir	12	8.27	0.688	0.199	7.20	9.30
Area 05, Well 5B Reservoir	12	10.2	1.01	0.293	8.50	12.0
Area 06, Well C1 Reservoir	12	13.8	3.26	0.941	7.90	20.0
Area 03, Well 3 Reservoir	12	12.9	1.56	0.452	11.0	17.0
Area 18, Camp 17 Reservoir	11	3.83	0.917	0.276	2.00	5.30
Area 18, Well 8 Reservoir	8	5.90	1.14	0.404	3.70	7.80
Area 19, Well U19c	11	1.40	0.565	0.170	0.670	2.30
Area 20, Well 20A Reservoir	11	8.83	8.50	2.56	2.40	29.0
Area 23, Swimming Pool	12	4.43	0.820	0.237	2.90	6.00
Area 25, Well J-12 Reservoir	12	7.87	5.15	1.49	4.80	23.0
Area 25, Well J-11 Reservoir	12	5.48	1.17	0.337	2.60	7.40

Tritium

The annual average concentration of ^{3}H in open reservoirs during 1991 was 7.4 x 10^{-8} µCi/mL (2.7 Bq/L). This concentration was 0.08 percent of the DCG for ^{3}H adjusted to an annual 4 mrem EDE. No single sampling location displayed an annual average different at the five percent significance level from the network annual average for ^{3}H. The individual results are listed in Appendix C, Attachment C.7, and a statistical discussion is presented at the beginning of Appendix C.

Plutonium

The annual average concentration of $^{239+240}Pu$ for all open reservoirs was 1.3 x 10^{-11} µCi/mL (4.8 x 10^{-4} Bq/L). This annual average was 0.2 percent of the DCG for ingested water adjusted to an annual 4 mrem EDE. None of the annual averages from any sampling location was different from the network average at the five percent significance level. All individual sampling results are tabulated in Appendix C, Attachment C.4.

The network annual average for ^{238}Pu was 6.9 x 10^{-12} µCi/mL (2.6 x 10^{-4} Bq/L). This value was 0.08 percent of the DCG for ^{238}Pu in potable water adjusted to an annual 4 mrem EDE. None of the open reservoir annual averages was statistically different from the network average at the five percent significance level. All individual results are presented in Appendix C, Attachment C.3. Statistical analyses results appear at the beginning of Appendix C.

Strontium

The annual average concentration of ^{90}Sr for all open reservoirs was 3.3 x 10^{-10} µCi/mL (1.2 x 10^{-2} Bq/L). This concentration was 0.1 percent of the ^{90}Sr DCG for ingested water adjusted to an annual 4 mrem EDE. None of the results from sampled locations were determined to be statistically different at the five percent significance level from

the network average. All individual sampling results are tabulated in Appendix C, Attachment C.1, Volume II.

NATURAL SPRINGS

Of the nine natural springs found onsite, seven were consistently sampled. The term *natural springs* was a label given to the spring-supplied pools located within the NTS. These springs were a source of drinking water for wild animals on the NTS.

Gross Beta

The locations of all natural springs and open reservoir sampled are shown in Figure 5.8 along with the annual average gross beta results. The annual average gross beta concentration for all samples collected from natural springs was 4.7×10^{-8} µCi/mL (1.7 Bq/L), which is 16 percent of the ^{40}K DCG adjusted to an annual 4 mrem EDE. None of the gross beta annual averages from natural springs was determined to be statistically different from the network average at the five percent significance level.

Table 5.12 presents a list of the gross beta averages at each natural spring sampling location. Appendix C, Attachment C.5, displays the individual sampling results. Statistical analyses are presented in at the beginning of Appendix C. The cause of the high values at Reitmann seep is unknown.

Tritium

The network annual average ^{3}H from samples taken at seven natural springs was 1.6×10^{-7} µCi/mL (5.9 Bq/L), which was 0.2 percent of the DCG for ^{3}H in drinking water adjusted to an annual 4 mrem EDE.

As with the ^{3}H results from open reservoirs, most of the sampling results from natural springs were not significantly different from the network average at the five percent significance level. The individual results are listed in Appendix C, Attachment C.7. The beginning of Appendix C contains the results of statistical analysis.

Plutonium

The annual average concentration of $^{239+240}Pu$ for all natural springs was 2.1×10^{-10} µCi/mL (8.0×10^{-3} Bq/L). This annual average was 3.5 percent of the $^{239+240}Pu$ DCG for ingested water adjusted to an annual 4 mrem EDE. None of the results was statistically different (at the five percent significance level) from the network average. Discussion of results may be found in the statistical evaluation of the data in Appendix C of Volume II. Individual sample results are listed in Attachment C.4, Appendix C.

The network annual average for ^{238}Pu was 4.3×10^{-11} µCi/mL (2.0×10^{-3} Bq/L). This annual average was 0.5 percent of the ^{238}Pu DCG for ingested water adjusted to an annual 4 mrem EDE. None of the sampling results was statistically different (at the five percent significance level) from the network average. All individual results are presented in Appendix C, Attachment C.3.

Table 5.12 NTS Natural Spring Gross Beta Analysis Results - 1991

Location	Number	Gross Beta Concentration x 10^{-9} µCi/mL: Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 05, Cane Spring	12	0.751	0.202	0.058	0.490	1.30
Area 07, Reitmann Seep	12	22.9	40.3	11.6	1.40	130.
Area 12, Captain Jack Spring	11	0.900	0.226	0.068	0.660	1.40
Area 12, Gold Meadows	8	2.90	0.994	0.352	1.70	4.80
Area 12, White Rock Spring	12	1.37	0.431	0.124	0.930	2.40
Area 16, Tippipah Spring	12	0.480	0.137	0.040	0.140	0.700
Area 29, Topopah Spring	6	0.837	0.151	0.0618	0.640	1.10

Strontium

The annual average concentration of ^{90}Sr for six of the natural springs was 8.5 x 10^{-10} µCi/mL (3.2 x 10^{-2} Bq/L). This concentration was 3 percent of the ^{90}Sr DCG for ingested water adjusted to an annual 4 mrem EDE. The sample from Area 29, Topopah Spring, was not collected for the strontium measurement due to low volume of water in July. The sample taken at Area 12, Gold Meadows, displayed an abnormal result. One reason for the abnormal result is that several water samples were uncharacteristically muddy, very high in dissolved solids. To obtain a sufficient sample, it is sometimes necessary to dig into the area. Therefore the strontium detected in this sample is more likely from the sediment. This result was not included in the network average. Discussion of these data is found in Appendix C, Volume II, and individual results may be found in Attachment C.1 following the statistical analysis.

CONTAINMENT PONDS

Nine containment ponds were sampled on a monthly basis. These ponds contained impounded waters from tunnel test areas (including the effluent liquid as it is discharged from the tunnel) and a contaminated laundry release point. All active containment ponds were fenced, restricted access areas posted with radiological warning signs. The average gross beta concentration for each containment pond location is shown in Figure 5.9. At each tunnel

Table 5.13 NTS Containment Pond Gross Beta Analysis Results - 1991

Location	Number	Gross Beta Concentration x 10^{-9} µCi/mL: Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 06, Decontamination Facility Pond	13	8.58	7.80	8.65	0.34	16.0
Area 12, E Tunnel Effluent	12	8.13	2.62	0.758	4.20	13.0
Area 12, N Tunnel Effluent	12	2.03	2.13	0.616	-1.50	5.50
Area 12, N Tunnel Pond No. 1	12	2.46	2.00	0.578	-0.370	5.80
Area 12, N Tunnel Pond No. 2	12	1.89	2.11	0.609	-0.930	5.60
Area 12, N Tunnel Pond No. 3	12	0.949	0.970	0.280	-0.085	3.00
Area 12, T Tunnel Effluent	12	20.6	8.71	2.51	14.0	46.0
Area 12, T Tunnel Pond No. 1	12	15.9	3.33	0.962	9.20	21.0
Area 12, T Tunnel Pond No. 2	11	16.8	3.46	1.04	10.0	23.0

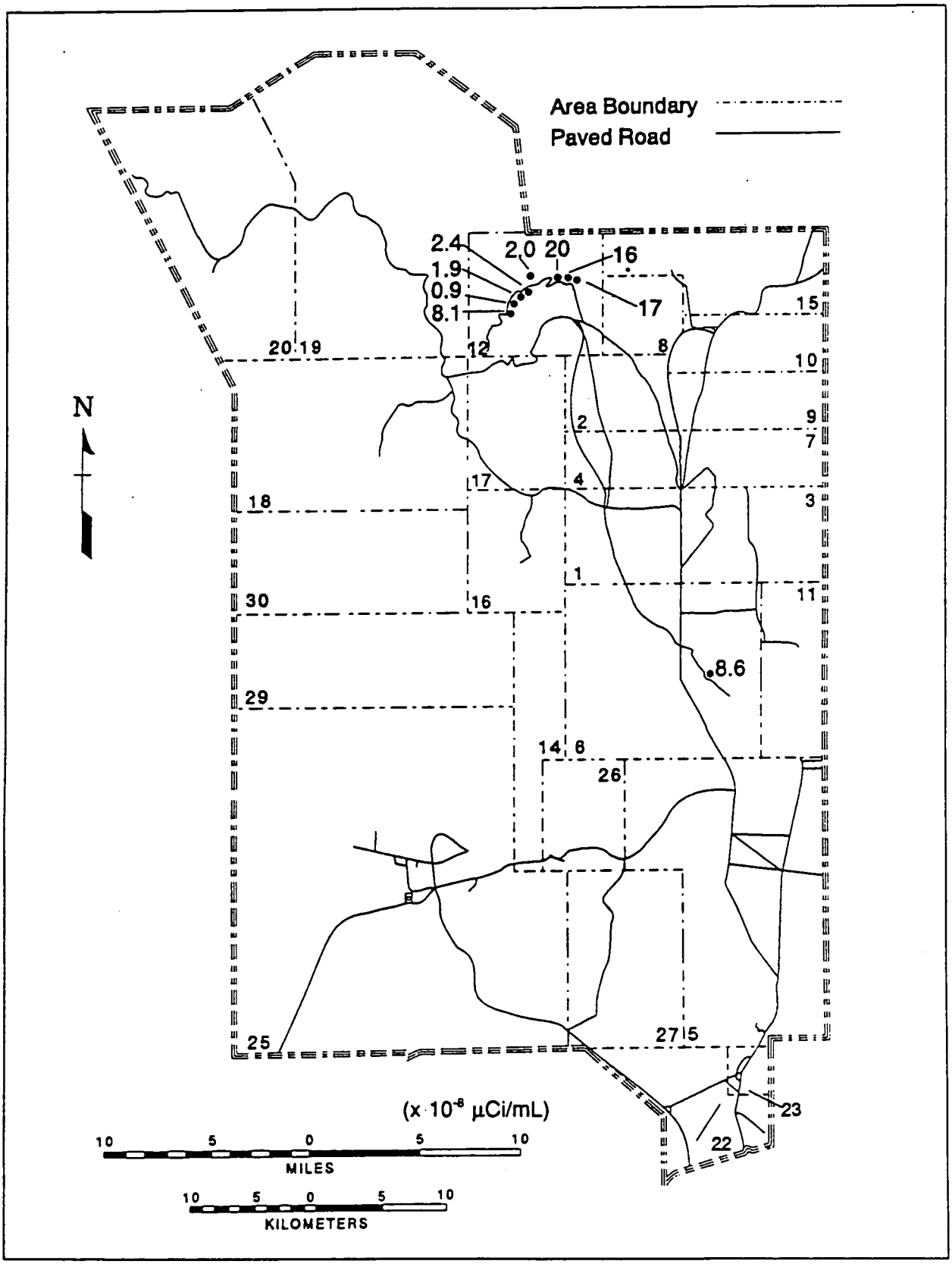

Figure 5.9 NTS Containment Pond Annual Average Gross Beta Concentrations - 1991

complex sampling was conducted at all active containment ponds and at the effluent discharge point. The Area 6 Decontamination Facility containment pond was grab sampled once per month. All samples taken from these sources were analyzed for ^{3}H, ^{238}Pu, $^{239+240}Pu$, gross beta, and gamma activity. The annual average of gross beta analyses from each sampling location is listed in Table 5.13. All data and statistical analyses are listed in Appendix C, Attachments C.1 through C.7.

T Tunnel

The annual average ^{3}H concentration in samples taken from two sequential containment ponds at the Area 12 T Tunnel complex was 6.7×10^{-3} µCi/mL (2.5×10^{5} Bq/L). Gross beta activity from samples taken at the same locations averaged 1.6×10^{-7} µCi/mL (5.9 Bq/L) during 1991, while annual concentrations of ^{238}Pu and $^{239+240}Pu$ averaged 5.6×10^{-11} (2.0×10^{-3} Bq/L) and 5.2×10^{-10} µCi/mL (1.9×10^{-2} Bq/L), respectively. The annual average ^{90}Sr concentration was 1.9×10^{-9} µCi/mL (7.0×10^{-2} Bq/L).

N Tunnel

The ^{3}H and gross beta annual average concentrations from samples taken from three containment ponds at the Area 12 N Tunnel complex were 3.0×10^{-4} and 1.8×10^{-6} µCi/mL (1.1×10^{4} and 0.7 Bq/L), respectively. Concentrations of $^{239+240}Pu$ and ^{238}Pu averaged 7.8×10^{-11} and 6.8×10^{-11} µCi/mL (2.9×10^{-3} and 2.5×10^{-3} Bq/L), respectively, during 1991. The annual average ^{90}Sr concentration was -1.5×10^{-9} µCi/mL (-5.6×10^{-3} Bq/L).

E Tunnel

Because very little water discharged from the Area 12 E Tunnel complex, there was not enough water in the containment ponds to sample during 1991. Therefore, sampling was conducted at the tunnel effluent discharge to the pond. The ^{3}H annual average concentration from samples taken of E Tunnel effluent was 2.1×10^{-3} µCi/mL (7.8×10^{4} Bq/L). The annual average beta activity from samples taken at this site was 8.1×10^{-8} µCi/mL (3.0 Bq/L). Concentrations of $^{239+240}Pu$ and ^{238}Pu averaged 5.9×10^{-9} and 7.3×10^{-10} µCi/mL (0.22 and 2.7×10^{-2} Bq/L), respectively. The annual ^{90}Sr concentration was 5.1×10^{-9} µCi/mL (0.19 Bq/L).

Area 6 Decontamination Facility Pond

During the decontamination of equipment at the Area 6 Decontamination Facility, the water used may become contaminated with various radionuclides. The water used during 1991 for decontamination was discharged into a nearby fenced and posted containment pond. A grab sample was taken and analyzed once per month. The annual average concentration of ^{3}H from these grab samples was 7.0×10^{-6} µCi/mL (2.6×10^{2} Bq/L), while beta activity averaged 8.6×10^{-8} µCi/mL (3.2 Bq/L) during 1991. Annual averages of ^{238}Pu and $^{239+240}Pu$ from samples taken at this pond were 8.8×10^{-11} and 9.9×10^{-11} µCi/mL (3.3×10^{-3} and 3.7×10^{-3} Bq/L), respectively. The annual ^{90}Sr concentration was 3.4×10^{-9} µCi/mL (0.13 Bq/L).

Radionuclide Migration Study Pond

At the Area 5 U5eRNM2S migration research well, a monthly grab sample was taken and analyzed for ^{3}H. The U5eRNM2S well was part of a radionuclide migration through groundwater study, which is discussed in Section 5.1.2 under "Radionuclide Migration Project."

SEWAGE LAGOONS

Samples from three sewage lagoons were collected during 1991. These lagoons are part of a closed system used for evaporative treatment of sanitary waste. They are located in Areas 6, 12, and 23. There was no known contact by the working population during 1991.

The ^{3}H annual average of four quarterly samples taken at the lagoons was 1.5×10^{-7} µCi/mL (5.6 Bq/L). The annual average gross beta concentration was 3.6×10^{-8} µCi/mL (1.3 Bq/L). Annual averages of $^{239+240}Pu$ and ^{238}Pu were 8.4×10^{-12} and 3.8×10^{-12} µCi/mL (3.1×10^{-4} and 1.4×10^{-4} Bq/L), respectively. The annual average ^{90}Sr concentration was 3.3×10^{-10} µCi/mL (1.2×10^{-2} Bq/L). No station was determined to be statistically different at the five percent significance level from the overall annual sewage lagoon average for any analyses result. All sampling results for sewage lagoons are presented in Appendix C, Attachments C.1 through C.7. Statistical discussions of these data are provided at the beginning of Appendix C.

5.2.1.6 RADIOACTIVITY IN GROUNDWATER

The principal water distribution system on the NTS is potentially the critical pathway for ingestion of waterborne radionuclides. Consequently, the water distribution system is sampled and evaluated frequently. The NTS water system consists of 13 supply wells, 9 of which supply potable water to onsite distribution systems (one of the wells reported on in 1990, Well 2 in Area 2, was shut down during all of 1991). The drinking water is pumped from the wells to the points of consumption. The supply wells are generally sampled on a monthly basis. Occasionally, some operational problems interrupt the sampling schedule. All drinking water is sampled weekly to provide a constant check of the end-use activity and to allow frequent the end-use activity comparisons to the radioactivity of the water in the supply wells. This section examines results from samples taken at the 13 supply wells which furnished the water for consumption and industrial use at the NTS during 1991. Well Ue5c in Area 5 was shut down during February 1991. Well Ue15d in Area 15 was shut down from August 1991 through December 1991. Water Well in Area 20 was shut down from May 1991 through December 1991. Well J-13 in Area 25 was shut down during May 1991. These wells were all shut down due to pump removal and repairs. All other wells described here (with the exception of Well 2 in Area 2, mentioned above) functioned continuously during 1991.

Each monthly sample was analyzed for ^{3}H, gross beta, and gamma activity. An extra sample was taken each quarter and analyzed for ^{238}Pu, $^{239+240}Pu$, and gross alpha activity. A sample was collected in July and analyzed for ^{90}Sr. Annual average results are presented for analyses conducted on groundwater samples in Table 5.14. (Comparison of the ^{3}H data in this table with the EPA data in Table D.4, Appendix D should not be attempted since different laboratory analytical procedures are used for the two data groups.)

SUPPLY WELLS

Water from 9 potable supply wells and 4 non-potable supply wells (shown in Figure 5.10) was used for a variety of purposes during 1991. Samples were collected from those wells which could potentially provide water for onsite human consumption. These data were used to help document the radiological characteristics of the NTS groundwater system. The sample results were maintained in a data base so that long-term trends and changes could be studied. Table 5.14 lists the potable and non-potable supply wells and their respective sampling

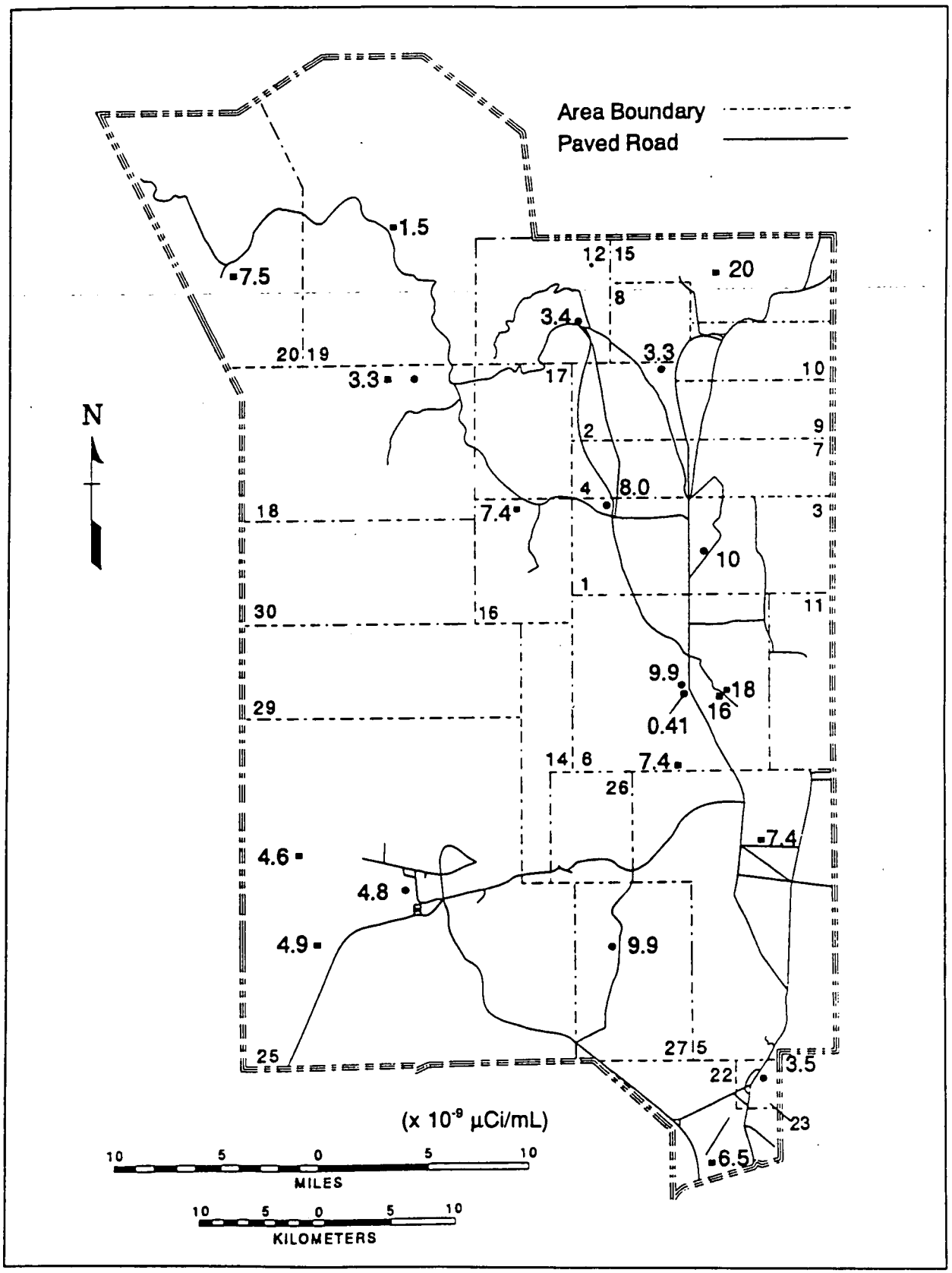

Figure 5.10 Annual Average Gross Beta in Supply Wells (■) and Potable Water (•) - 1991

stations. Individual sampling results are presented in Appendix C, Attachments C.1 through C.7, and statistical discussions of the samples may be found at the beginning of the appendix.

Gross Beta

The network average gross beta activity for supply wells was 8.6×10^{-9} µCi/mL (0.32 Bq/L), which was 0.12 percent of the DCG for ^{40}K and 0.86 percent of the DCG for ^{90}Sr. In previous reports (Scoggins 1983 and Scoggins 1984), it was shown that the majority of gross beta activity was attributable to naturally occurring ^{40}K. The gross beta annual averages are shown at their respective supply well sampling locations in Figure 5.10.

Table 5.14 NTS Supply Well Radioactivity Averages - 1991

	µCi/mL					
Description	Gross Beta	^{3}H	$^{239+240}Pu$	^{238}Pu	Gross Alpha	^{90}Sr[a]
Potable Water Supply Wells						
Area 05, Well 5C	9.0×10^{-9}	-2.0×10^{-6}	1.4×10^{-11}	2.4×10^{-11}	1.2×10^{-8}	1.4×10^{-10}
Area 06, Well 4	7.4×10^{-9}	-2.0×10^{-6}	4.0×10^{-12}	-2.5×10^{-12}	6.8×10^{-9}	2.9×10^{-10}
Area 06, Well C	1.8×10^{-8}	-1.7×10^{-6}	1.0×10^{-13}	1.0×10^{-13}	1.9×10^{-8}	-1.2×10^{-10}
Area 06, Well C1	1.6×10^{-8}	2.2×10^{-6}	2.6×10^{-11}	6.4×10^{-11}	1.7×10^{-8}	1.6×10^{-10}
Area 16, Well UE-16d	7.4×10^{-9}	-6.2×10^{-9}	4.6×10^{-12}	9.2×10^{-12}	1.6×10^{-8}	1.8×10^{-11}
Area 18, Well 8	3.3×10^{-9}	8.2×10^{-9}	6.5×10^{-12}	2.2×10^{-12}	7.0×10^{-10}	-5.6×10^{-11}
Area 22, Army Well No. 1[a]	6.5×10^{-9}	1.2×10^{-6}	2.4×10^{-11}	1.4×10^{-11}	6.5×10^{-9}	-4.5×10^{-11}
Area 25, Well J-12	4.9×10^{-9}	-3.1×10^{-6}	1.9×10^{-12}	6.5×10^{-12}	1.3×10^{-9}	-4.1×10^{-10}
Area 25, Well J-13	4.6×10^{-9}	2.1×10^{-6}	2.7×10^{-13}	7.0×10^{-13}	1.2×10^{-9}	-1.8×10^{-10}
Non-Potable Water Supply Wells						
Area 05, Well UE-5c	7.4×10^{-9}	6.4×10^{-6}	5.6×10^{-11}	2.9×10^{-11}		1.6×10^{-10}
Area 15, Well UE-15d	2.0×10^{-8}	4.0×10^{-6}	-3.0×10^{-11}	2.4×10^{-11}		
Area 19, Well UE-19c	1.5×10^{-9}	6.8×10^{-6}	4.3×10^{-11}	2.7×10^{-11}		2.4×10^{-10}
Area 20, Water Well U-20	7.5×10^{-9}	3.9×10^{-6}	-3.2×10^{-11}	1.7×10^{-11}	7.1×10^{-9}	

(a) ^{90}Sr values are for one sample.

Tritium

There were no potable or non-potable supply wells sampled that had annual average concentrations different at the five percent significance level from the network annual average ^{3}H concentrations. These annual average concentrations were -3.4×10^{-9} µCi/mL (-0.13 Bq/L) for the potable supply wells and 5.3×10^{-6} µCi/mL (2.0 Bq/L) for the non-potable supply wells. When analysis of a sample yields a result that is less than the background activity, subtraction of background from that result yields a negative number. This process is statistically probable when the activity of the radionuclide in the sample is less than the detection capability of the counting equipment. The annual average for several sample results can therefore be positive or negative. These annual averages both were less than 0.06 percent of the DOE Order 5400.5 DCG for tritium in ingested water. The annual ^{3}H averages for the respective sampling locations are shown in Table 5.14.

In addition, quarterly ^{3}H analyses were performed for the nine potable water supply wells by the method of tritium enrichment described in 4.1.1.3. Most of these results were below the minimum detectable activities for the corresponding measurements; the values substantiate the results obtained by the conventional tritium analyses, which show that the water from the potable supply wells has extremely low tritiated water concentrations. It should be noted that commercially available distilled water was used for the background matrix for both the conventional and enrichment analysis methods. Clearly the tritium concentration in the commercial product was frequently higher than in the samples themselves resulting in negative results. This was particularly pronounced in the results obtained from the enrichment method. Thus, except for possible statistical fluctuations, the negative values indicate that the water from the potable supply wells contained less tritium than the commercially available distilled water.

Plutonium

The annual average network $^{239+240}Pu$ concentration of 5.0×10^{-12} µCi/mL (1.9×10^{-4} Bq/L) was 0.08 percent of the DCG for this radionuclide adjusted to an annual 4 mrem EDE. The annual average ^{238}Pu concentration of 2.0×10^{-11} µCi/mL (7.4×10^{-4} Bq/L) was 0.2 percent of the DCG adjusted to an annual 4 mrem EDE. The annual averages for these radionuclides are shown in Table 5.14.

Gross Alpha

The network average gross alpha activity for supply wells was 6.3×10^{-9} µCi/mL (0.23 Bq/L), which was 42 percent of the drinking water standard of 15×10^{-9} µCi/mL. None of the annual averages from samples collected at the supply well locations were statistically different from the network average. The gross alpha annual averages for supply wells are shown in Table 5.14.

Strontium

The annual average network for supply wells was 3.0×10^{-12} µCi/mL (1.1×10^{-4} Bq/L), which was 0.01 percent of the MCL for ^{90}Sr in drinking water adjusted to an annual 4 mrem EDE. None of the annual averages from any sampling location was different from the network average at the five percent significance level. Table 5.14 shows the annual ^{90}Sr averages for the supply well locations.

5.2.1.7 RADIOACTIVITY IN DRINKING WATER

As a check on any effect the water distribution system might have on end-use activity, nine consumption points were sampled during the reporting period. In order to be certain that all of the water available for consumption was being considered, each drinking water system had in previous years been identified and sampled. The NTS contained five drinking water systems, each fed by a series of supply wells during most of 1991. The components of the five systems were as shown in Table 5.15. The five drinking water systems, fed by the nine potable supply wells on the NTS, are the source of the water from eight of the consumption points; water from the ninth consumption point, Area 6, Bottled Water, is provided by a commercial vendor from Las Vegas.

Table 5.15 NTS Drinking Water Sources - 1991

Supply Well	End-point
Well C, C1, 4	Area 3, Cafeteria
	Area 27, Cafeteria
	Area 6, Cafeteria
Well 8	Area 2, Rest Room
	Area 12, Cafeteria
Well 16D	Area 1, Building 101
Well 5C, Army #1	Area 23, Cafeteria
Well J-12, J-13	Area 25, Building 4221
None	Area 6, Bottled Water

Gross Beta

The annual average gross beta concentration in water samples from nine potable water locations was 5.9×10^{-9} µCi/mL (0.22 Bq/L). This annual average was 2 percent of the EPA-equivalent DCG for ^{40}K adjusted to an annual 4 mrem EDE.

None of the gross beta annual averages from potable water locations was determined to be statistically different from the network average. The locations of all potable water stations are shown in Figure 5.10, along with their gross beta annual averages.

Tritium

The annual average ^{3}H concentration in samples taken at nine potable water locations was -1.6×10^{-6} µCi/mL (-0.59 Bq/L). This concentration was less than 0.01 percent of the DOE Order 5400.5 DCG adjusted to an annual 4 mrem EDE. None of the annual averages from samples collected at the potable water stations were statistically different from the network average.

Plutonium

The annual averages of $^{239+240}Pu$ and ^{238}Pu from quarterly samples taken at nine potable water sampling locations were respectively 6.5×10^{-12} µCi/mL (2.4×10^{-4} Bq/L) and 1.1×10^{-11} µCi/mL (4.1×10^{-4} Bq/L). These averages, composed of results which were below the detection limits, were 0.01 and 0.1 percent of the DCGs for $^{239+240}Pu$ and ^{238}Pu, respectively. None of the annual averages from individual locations were statistically different from the network averages.

Gross Alpha

In accordance with the National Primary Drinking Water Regulation, gross alpha measurements were conducted on the drinking water systems for 1991. Results from most samples averaged over 5×10^{-9} µCi/mL (5 pCi/L; 0.19 Bq/L), which is the screening level for ^{226}Ra analysis. Samples from the nine potable water supply wells were collected and analyzed for ^{226}Ra. The annual average gross alpha results for samples collected quarterly from all potable water endpoints on the NTS, are shown in Table 5.14. The ^{226}Ra results are shown in Table 5.16. None were above 2×10^{-9} µCi/mL (0.07 Bq/L); thus, onsite drinking water was in compliance with drinking water regulations.

Table 5.16 Radium-226 Analysis Results for NTS Drinking Water - 1991

Potable Supply Well	^{226}Ra Results (pCi/L)
Area 05, Well5c	<1.3
Area 06, Well4	<0.6
Area 06, Well C	<1.6
Area 06, Well C1	<1.3
Area 16, Well 16d	<1.3
Area 18, Well 8	<1.1
Area 22, Army Well No. 1	<1.1
Area 25, Well J-12	<1.3
Area 25, Well J-13	<1.4

Strontium

^{90}Sr concentrations for the nine potable water consumption points at which samples were taken are listed in Table 5.15. The annual network average for these nine locations was 4.8 x 10^{-11} µCi/mL (1.8 x 10^{-3} Bq/L), which was 0.2 percent of the DCG for ^{90}Sr adjusted to an annual 4 mrem EDE. No potable water locations displayed annual average concentrations different at the five percent significance level from the network average.

5.2.1.8 EXTERNAL GAMMA EXPOSURES - ONSITE AREA

TLDs were deployed at 187 locations throughout the NTS to measure ambient gamma radiation levels. These dosimeters were manufactured by Panasonic and designed to measure the typical gamma conditions present in the environment. The TLDs were deployed on the NTS at locations with radiological conditions ranging from background levels to areas with known contamination. This section presents the results from analysis of TLDs deployed during each quarter of 1991.

The average levels of environmental gamma exposures recorded during 1991 were statistically different within different NTS areas, but a pattern of differences cannot be elucidated because of vastly different numbers of samples from the areas involved. TLDs measured gamma exposures which ranged from 69 mR/year at the Area 23, Building 650 Roof and Area 23, Building 650 Dosimetry stations, to 3883 mR/year at the Area 5, RWMS MSM-2 East station. A plot of the data shows that the TLD results were normally distributed about a mean of 153 mR/year when obvious outliers were not included. These data may be described as the NTS gamma exposure rates which were not influenced by radiological areas. The remaining data range from 609 to 3883 mR/year. The TLDs collecting these data were deployed at locations with known contamination from, for example, weapons tests or radioactive material storage.

Statistical analyses of the data are presented in Appendix F; Table F.1 contains a summary of the individual TLD results. Table 5.17 displays the results of gamma monitoring conducted at the NTS boundary. These locations were close to the boundary of the NTS and were

reachable only via helicopter. The data collected at these locations were statistically not different from the data collected from the control locations. The boundary TLDs were not exchanged at the end of the fourth quarter due to management concern over hazardous flying conditions. Consequently, the fourth quarter exposure rates listed in Table 5.17 are for the period Oct. 1, 1991 to April 9, 1992.

A group of locations which were not, to the best available knowledge, influenced by radiological contamination, served as controls for the NTS. The data from these locations are presented in Table 5.18. The overall network exposure range for the control locations for 1991 was 0.19 to 0.42 mR/day, with an average exposure rate of 0.31 mR/day or 112 mR/year.

An investigation of historical trends in onsite environmental gamma levels as measured by TLDs demonstrated, except for data from 1988 which is considered less reliable than that for other years due to a calibration problem, the data showed no significant differences between years. The description of this analysis is found in Volume II, Appendix G.

5.2.1.9 SPECIAL ENVIRONMENTAL STUDIES

The Basic Environmental Compliance and Monitoring Program (BECAMP) conducts special environmental studies on the NTS that include (1) investigating the movement of radionuclides on and around the NTS through horizontal movement, water-driven erosion, vertical migration, and wind-driven erosional resuspension; (2) development of a human dose-assessment model specific to the environmental and radiological conditions of the NTS; and (3) preparation of annual thematic, peer-reviewed publications which address important issues related to the potential environmental impacts of past, present, and future activities on the NTS. The results of 1991 BECAMP investigations relative to onsite radiological monitoring are summarized in the following sections.

MOVEMENT OF RADIONUCLIDES ON AND AROUND THE NTS

Investigations into the movement of radionuclides on and around the NTS were concentrated on the monitoring of wind-driven resuspension from a plutonium-contaminated site on the Tonopah Test Range. Monitoring of plutonium and americium particle emissions from soils contaminated during nuclear testing is important for several reasons. First, quantification of the potential human exposure from inhalation of particles, which is the major exposure pathway from transuranic radionuclides, may be accomplished. Second, a determination may be made of the transuranic radionuclide aerosol emission rates by wind erosion so that a source term can be derived for calculating population or occupational doses in the event of significant, long-term transport of aerosols. Finally, information provided by resuspension monitoring is the basis of criteria that will determine soil transuranic radionuclide concentrations for management and remediation of contaminated soils.

In 1991, work continued on the characterization of resuspension processes from the Clean Slate III site on the Tonopah Test Range. For nine months of the year, air samples were collected biweekly with several different types of samplers: (1) high-volume air samplers for the determination of air radionuclide concentrations and particle mass loading, (2) cascade impactors for determination of the aerosol particle-size distribution, and (3) array air samplers that are used to measure the vertical gradient of radioactivity in the air layer a few meters above the soil. Weather and micrometerological boundary-layer data were also collected from a station at the site. Once all the samples have been analyzed, a report will be written

Table 5.17 NTS Boundary Gamma Monitoring Result Summary - 1991

Area	Location	First Quarter (mR/day)	Second Quarter (mR/day)	Third Quarter (mR/day)	Fourth Quarter[a] (mR/day)	Average[a] (mR/day)	1990 Annual Exposure (mR/yr)	1991 Annual Exposure (mR/yr)
03	Boundary TLD Station 358	0.27	0.17	0.22	0.20	0.22	88	79
08	Boundary TLD Station 356	0.52	0.41	0.46	0.44	0.46	180	167
10	Boundary TLD Station 357	0.29	0.24	0.23	• 0.22	0.24	95	89
11	Boundary TLD Station 359	0.51	0.39	0.45	0.41	0.44	175	165
11	Boundary TLD Station 360	0.25	0.16	0.20	0.17	0.20	81	71
12	Boundary TLD Station 355	0.37	0.29	•	0.30	0.32	114	116
19	Boundary TLD Station 352	0.32	0.23	0.28	0.27	0.27	113	101
19	Boundary TLD Station 353	0.54	0.41	0.45	0.46	0.46	157	169
19	Boundary TLD Station 354	0.49	0.40	0.45	(0.16)[b]	(0.38)	165	(137)
20	Boundary TLD Station 350	0.59	0.47	0.52	0.52	0.52	207	191
20	Boundary TLD Station 351	0.52	0.42	0.45	(0.30)[b]	(0.42)	173	(154)
22	Boundary TLD Station 346	0.26	0.16	0.20	0.21	0.21	83	75
28	Boundary TLD Station 347	0.35	0.25	0.30	0.27	0.29	119	107
30	Boundary TLD Station 349	•	0.42	0.42	0.42	0.42	174	154
31	Boundary TLD Station 348	0.47	0.37	0.29	0.43	0.39	165	142

• Missing or Not Collected TLD

(a) Fourth quarter exposure rates are for the period Oct. 1 1991 to April 9, 1992.

(b) Low readings ascribed to heavy snow cover.

Table 5.18 NTS TLD Control Station Comparison - 1985-1991

		Exposure Rate (mR/day)						
Area	Station	1985	1986	1987	1988	1989	1990	1991
5	Well 5B	0.26	0.22	0.32	0.43	0.36	0.34	0.37
6	CP-6	0.17	0.13	0.21	0.36	0.27	0.25	0.24
6	Yucca Oil Storage	0.21	0.22	0.30	0.29	0.32	0.32	0.33
23	Bldg. 650 Dosimetry	0.13	0.31	0.14	0.26	0.19	0.20	0.19
23	Bldg. 650 Roof	0.12	0.13	0.17	0.24	0.18	0.19	0.19
23	Post Office	0.13	0.16	0.24	0.29	0.23	0.23	0.24
25	HENRE Site	0.28	0.27	0.34	0.47	0.38	0.39	0.40
25	NRDS Warehouse	0.28	0.28	0.39	0.46	0.38	0.39	0.39
27	Cafeteria	0.29	0.27	0.38	0.49	0.32	0.40	0.42
	Network Average	0.21	0.22	0.28	0.37	0.29	0.30	0.31

containing the results of the investigation and a relevant site assessment as to the movement of radionuclides from the site by wind-driven erosion. In addition, the draft "Study Plan for Monitoring Resuspension of Radioactive Aerosols at Nevada Test Site" developed for the Clean Slate III investigation will be finalized in a report.

Other efforts in 1991 included the completion of three BECAMP Quality Assurance Detailed Procedures for the use of low-energy gamma-ray detectors in field surveys for the determination of ^{241}Am concentrations in NTS soils. These procedures were used in the development of a study plan to investigate the movement of radionuclides by water-driven erosion. The draft study plan, prepared this year, focused on the movement of radionuclides by storm-channel erosion through a plutonium-contaminated site in NTS Area 11. The study plan will be completed early in 1992 with a baseline *in situ* survey to be conducted shortly thereafter.

HUMAN DOSE-ASSESSMENT MODEL

The BECAMP dose-assessment model is an extension of the Nevada Applied Ecology Group (NAEG)/NTS model that was used to estimate the internal dose to man from the inhalation and ingestion of $^{239+240}$Pu. The model has been modified to include (1) the external dose pathway for gamma-emitting radionuclides, (2) a multi-compartment gut model for calculating the dose to the gut, (3) the gamma-exposure pathway, (4) the radionuclides ^{60}Co, ^{90}Sr, ^{152}Eu, ^{155}Eu, ^{238}Pu, and ^{241}Am that are found in measurable quantities on the NTS, (5) codification of the internal and external doses in the model for all radionuclides, and (6) the radionuclides ^{101}Rh, ^{102}Rh, ^{125}Sb, ^{134}Cs, and ^{174}Lu that are found in small quantities on the NTS. The results of a sensitivity and uncertainty analyses of the NAEG model, completed in 1989, showed the air pathway as the critical pathway for human exposure to plutonium, and the soil plutonium concentration and the factors controlling air concentration are the most important environmental parameters. The results of the analyses were presented in a peer-reviewed publication released this year (Kercher and Anspaugh 1991).

Also in 1991, work began on estimation of realistic uncertainties of model input parameters. This investigation involves the analyses of NTS soil-plutonium concentrations and resuspension data. A related investigation was also initiated and involves the development of analyses of uncertainties in predicted radionuclide body burdens and doses from discrete and continuous stochastic radionuclide source terms. Specifically, expressions for the uncertainty of body burdens were derived from a linear model of environmental transport and human metabolism in terms of uncertainty in soil radionuclide concentrations. The results of the theoretical analysis indicate that (1) the rate of metabolism has an effect on the uncertainty in body burdens of radionuclides for situations where the exposure to the radionuclide changes over time in a stochastic way, (2) successive random fluctuations produce a less uncertain result than random inputs determined at the outset of exposure and then fixed on the period of exposure, and (3) partially correlated random fluctuations produce 1/(1-a) greater uncertainties than purely random fluctuations, where "a" is the partial correlation coefficient. The results of the investigation will be presented in a report that should be completed early in 1992.

THEMATIC, PEER-REVIEWED PUBLICATIONS

In 1991, a paper dealing with the possible differential movement of ^{238}Pu and $^{239+240}$Pu from soil to plants and animals on the NTS was completed after additional uncertainty analyses were conducted. Data obtained during a cattle-grazing study in Area 13 of NTS, conducted by EPA for the NAEG from 1973 to 1976, indicated that differential movement of plutonium isotopes from soil to cattle tissues may have occurred (Gilbert et al. 1989). If this phenomenon

is occurring, it should be taken into account when evaluating compliance with radiation protection standards and conducting health risk assessments. In this investigation, Monte Carlo parameter uncertainty and sensitivity analyses were conducted to test whether the fractional transfer of ^{238}Pu from the gastro-intestinal (GI) tract to blood serum, muscle, and liver for a herd of 17 cattle was greater than that of $^{239+240}Pu$. The uncertainty analyses do not refute the hypothesis that ^{238}Pu was transported more readily than $^{239+240}Pu$ to Area 13 cattle tissues. The paper is currently being reviewed and will be submitted to the Health Physics journal for publication.

A second report by BECAMP investigators in 1991 was on the findings and conclusions from the Radionuclide Inventory and Distribution Program (RIDP). In the report, McArthur (1991) combines the results from the series of five RIDP reports to provide an integrated picture of the current levels of soil radioactivity on the NTS. The report includes new distribution maps of the estimated current inventories of the nine most important manmade radionuclides on the NTS (^{60}Co, ^{90}Sr, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{241}Am, ^{238}Pu, and $^{239+240}Pu$).

5.2.2 OFFSITE ENVIRONMENTAL SURVEILLANCE

The primary purpose of the offsite environmental surveillance program operated by EPA EMSL-LV is to detect any radioactivity related to current NTS activities which could potentially result in human exposure. Therefore, monitoring is concentrated on possible human exposure pathways and monitoring locations are generally in inhabited areas around the NTS. Monitoring sites are not designed to provide full spatial characterization of the offsite area, nor is the monitoring designed to detect all types of radioactivity arising from all natural and manmade sources.

Possible exposure pathways monitored include air, water, milk, domestic and game animals, and locally grown fruits and vegetables. Alpha, beta, and gamma radiation in air are monitored in the Air Surveillance Network, comprised of 33 continuously operating stations around the NTS and 76 standby samplers located in states west of the Mississippi River. Noble gases are monitored with custom-designed samplers at 21 locations around the NTS. Tritium-in-air samplers are located at 22 sites, many at the same locations as the noble gas samplers. Groundwater and some surface water supplies are sampled regularly in the Long-Term Hydrological Monitoring Program. Water sampling locations include wells on the NTS and locations in the offsite area. The Milk Surveillance Network consists of 23 locations sampled monthly, including family-owned cows and goats as well as commercial dairies in the immediate offsite area. In addition, most major milksheds west of the Mississippi River are sampled annually through the standby milk surveillance network. Cattle from ranches in the offsite area, mule deer from the NTS, and bighorn sheep hunted in Nevada are all included in the Biomonitoring Network, as are locally grown fruits and vegetables obtained as available from residents.

In addition to the networks described above, external gamma radiation is monitored by the Pressurized Ion Chamber (PIC) Network and the Thermoluminescent Dosimeter (TLD) Network. The PIC network includes 29 stations located in the offsite area that are connected by satellite telemetry to the NTS for real-time data collection. Approximately 72 local residents voluntarily participate in the TLD network and another 131 TLDs are located at fixed environmental stations. A number of residents, as well as potentially occupationally exposed workers, participate in the Internal Dosimetry Network which includes an annual whole body and lung count and urinalysis.

The results of monitoring conducted in 1991 are discussed in the following subsections for each of the environmental surveillance networks mentioned above but specifically described in Chapter 4. No major accidental release of radionuclides occurred at the NTS in 1991, as has been the case for many years. Small releases of radionuclides (e.g., from tunnel purgings, drillbacks) occurred even though operations were conducted under stringent safety criteria and none were detected by the offsite monitoring networks.

5.2.2.1 AIR MONITORING NETWORKS

Atmospheric monitoring equipment includes air samplers, noble gas samplers, and atmospheric moisture (tritium-in-air) samplers. The air samplers are divided into two networks: the Air Surveillance Network (ASN) routinely samples air in the offsite area surrounding the NTS and the Standby Air Surveillance Network (SASN) which consists of at least two samplers located in each state west of the Mississippi River. The SASN samplers are activated for a brief period (one to two weeks) each quarter to maintain operational readiness and provide data on background radioactivity levels. The primary purpose of the ASN is to detect airborne radioactivity that may be related to NTS activities. In case of a venting on the NTS or suspected increase in airborne radioactivity, the SASN is activated so that the fallout path, area, and duration can be estimated and possible inhalation exposure of the general public calculated.

Noble gas and tritium-in-air samplers are located in every community near the NTS. The noble gas and tritium-in-air sampler networks include both continuously operated and standby samplers. In recent years the concentration of ^{85}Kr in the atmosphere has been increasing while radioxenons and tritium are only rarely detected. Xenon-133 and ^{135}Xe have occasionally been detected because of releases at the NTS due to drillbacks, ground seepage, and tunnel purging. In order to detect these releases, the network stations circumscribe the NTS, as small releases can occur when the wind is from any direction.

AIR AND STANDBY AIR SURVEILLANCE NETWORKS

In 1991, the ASN comprised 33 routinely operated stations in Nevada, Utah, and California, while the SASN consisted of 76 air samplers located in states throughout the West. Figure 4.5 (Chapter 4) depicts the locations of the ASN stations and Figure 4.6 (Chapter 4) displays the locations of the SASN stations. Changes to the ASN during 1991 included relocation of the Scotty's Junction station from Holloways' Ranch to Terrell's Ranch on June 24. This change involved moving the sampler approximately one-half mile. On December 1, this station, the Amargosa Valley Community Center station (Amargosa Valley, Nevada), and the G. L. Coffer-Fleur-de-Lis Ranch station (Beatty, Nevada) were reassigned to the Yucca Mountain monitoring network.

Gamma spectroscopy was performed on all air samples; the majority of the samples were gamma-spectrum negligible. Infrequently, naturally occurring ^{7}Be was detected, averaging 2.3×10^{-13} µCi/mL. As in previous years, the gross beta results from both networks consistently exceeded the minimum detectable concentration (MDC). However, average gross beta activity decreased in 1991, from an average of 0.022 pCi/m^3 in 1990 to an average of 0.018 pCi/m^3. This decrease in gross beta activity was evident in 62 (82%) of the SASN samples and all of the ASN samples. Table 5.19 provides summary gross beta results for the ASN and Table 5.20 contains summary gross beta results for the SASN. Figure 5.11 depicts mean monthly gross beta averages from 1989 through the end of 1991 for eight ASN stations around the NTS. The stations used in computation of the means were Alamo, Amargosa

Table 5.19 Gross Beta Results for the Air Surveillance Network - 1991

Sampling Location	Number of days Sampled[b]	Gross Beta Concentration x 10^{-12} µCi/mL[a] Maximum	Minimum	Average
Death Valley Junction, CA	365	0.036	0.004	0.017
Furnace Creek, CA	365	0.100	0.003	0.026
Shoshone, CA	365	0.056	0.005	0.019
Alamo, NV	365	0.027	0.011	0.015
Amargosa Valley, NV	364	0.036	0.007	0.017
Amargosa Valley Community Center, NV	336	0.042	0.004	0.019
Austin, NV	365	0.035	0.001	0.014
Beatty, NV	359	0.036	0.008	0.018
Beatty, NV Coffer-Fleur-de-Lis Ranch	335	0.032	0.001	0.013
Caliente, NV	365	0.039	0.002	0.018
Clark Station, NV Stone Cabin Ranch	365	0.033	0.006	0.016
Currant, NV Blue Eagle Rn	365	0.050	0.006	0.018
Ely, NV	365	0.023	0.004	0.014
Goldfield, NV	358	0.032	0.007	0.017
Groom Lake, NV	345	0.033	0.006	0.017
Hiko, NV	358	0.032	0.003	0.017
Indian Springs, NV	365	0.037	0.009	0.019
Las Vegas, NV	360	0.100	0.008	0.022
Nyala, NV	358	0.041	0.007	0.013
Overton, NV	365	0.042	0.008	0.021
Pahrump, NV	365	0.043	0.005	0.018
Pioche, NV	364	0.036	0.005	0.017
Rachel, NV	365	0.053	0.005	0.019
Scotty's Junction, NV Holloway's Ranch	175[c]	0.039	0.006	0.018
Scotty's Junction, NV Terrell's Ranch	161[d]	0.037	0.003	0.022
Sunnyside, NV	365	0.040	0.002	0.015
Tonopah, NV	365	0.027	0.006	0.015
Tonopah Test Range, NV	365	0.039	0.000	0.016
Twin Springs, NV Fallini's Ranch	365	0.104	0.010	0.022
Cedar City, UT	365	0.034	0.007	0.016
Delta, UT	365	0.066	0.010	0.021
Milford, UT	365	0.059	0.003	0.021
St. George, UT	364	0.043	0.005	0.019
Salt Lake City, UT	365	0.037	0.008	0.017

[a] 10^{-12} µCi/mL = pCi/m^3; multiply the result by 0.037 to obtain Bq/m^3.
[b] Days sampled are determined from filter change dates.
[c] Station moved to Terrell's Ranch on June 24, 1991.
[d] Station moved from Holloway's Ranch on June 24, 1991.

Table 5.20 Gross Beta Results for the Standby Air Surveillance Network - 1991

Sampling Location	Number of days Sampled	Gross Beta Concentration x 10^{-12} µCi/mL[(a)] Maximum	Minimum	Average
Globe, AZ	30	0.025	0.013	0.017
Kingman, AZ	28	0.033	0.006	0.019
Tuscon, AZ	29	0.029	0.022	0.026
Winslow, AZ	28	0.039	0.009	0.024
Yuma, AZ	37	0.028	0.006	0.016
Little Rock, AR	33	0.018	0.008	0.013
Alturas, CA	21	0.018	0.005	0.010
Baker, CA	31	0.048	0.019	0.031
Bishop, CA	36	0.045	0.014	0.013
Chico, CA	27	0.018	0.010	0.014
Indio, CA	21	0.039	0.020	0.027
Lone Pine, CA	8	0.011	0.011	0.011
Needles, CA	21	0.011	0.006	0.008
Ridgecrest, CA	27	0.041	0.005	0.024
Santa Rosa, CA	28	0.017	0.005	0.009
Cortez, CO	35	0.025	0.017	0.022
Denver, CO	27	0.037	0.015	0.025
Grand Junction, CO	34	0.088	0.012	0.033
Mountain Home, ID	27	0.031	0.003	0.014
Nampa, ID	28	0.010	0.000	0.007
Pocatello, ID	21	0.012	0.009	0.010
Fort Dodge, IA	28	0.034	0.016	0.023
Iowa City, IA	21	0.031	0.014	0.024
Dodge City, KS	28	0.022	0.011	0.016
Monroe, LA	28	0.024	0.018	0.021
Minneapolis, MN	20	0.026	0.017	0.022
Clayton, MO	29	0.021	0.008	0.016
Joplin, MO	28	0.018	0.008	0.014
St. Joseph, MO	28	0.020	0.016	0.018
Great Falls, MT	35	0.019	0.007	0.013
Kalispell, MT	28	0.029	0.009	0.017
Miles City, MT	21	0.029	0.015	0.020
North Platte, NE	14	0.024	0.021	0.022
Adaven-Uhalde Ranch, NV	56	0.040	0.007	0.016
Battle Mountain, NV	26	0.050	0.012	0.027
Blue Jay, NV	29	0.033	0.015	0.023
Clark Station, NV	29	0.034	0.003	0.018
Currant-Angle Worm Ranch, NV	29	0.036	0.014	0.024
Currie Maint. Station, NV	30	0.028	0.006	0.018
Duckwater, NV	29	0.024	0.010	0.019
Elko-Phillips 66 Truck Stop,NV	29	0.029	0.008	0.018
Eureka, NV	20	0.016	0.001	0.007
Fallon, NV	35	0.068	0.011	0.028

(a) 10^{-12} µCi/mL = pCi/m^3; multiply the result by 0.037 to obtain Bq/m^3.

Table 5.20 (Gross Beta Results for the Standby Air Surveillance Network - 1991, cont.)

Sampling Location	Number of days Sampled	Gross Beta Concentration x 10^{-12} µCi/mL[a] Maximum	Minimum	Average
Geyser Ranch, NV	26	0.017	0.010	0.014
Lovelock, NV	29	0.060	0.001	0.021
Lund, NV	21	0.018	0.007	0.013
Mesquite, NV	20	0.010	0.006	0.008
Reno, NV	28	0.043	0.004	0.021
Round Mountain, NV	29	0.019	0.012	0.016
Wells, NV	23	0.038	0.010	0.020
Winnemucca, NV	29	0.050	0.012	0.025
Albuquerque, NM	35	0.025	0.010	0.016
Carlsbad, NM	27	0.012	0.004	0.008
Shiprock, NM	36	0.039	0.006	0.019
Bismarck, ND	28	0.024	0.015	0.019
Fargo, ND	27	0.026	0.013	0.020
Williston, ND	21	0.029	0.023	0.026
Muskogee, OK	21	0.019	0.014	0.016
Burns, OR	21	0.011	0.009	0.010
Medford, OR	20	0.035	0.008	0.019
Rapid City, SD	21	0.012	0.010	0.011
Amarillo, TX	37	0.022	0.013	0.018
Austin, TX	29	0.027	0.011	0.019
Midland, TX	28	0.010	0.003	0.006
Tyler, TX	31	0.022	0.013	0.017
Bryce Canyon, UT	46	0.016	0.000	0.009
Enterprise, UT	35	0.029	0.015	0.019
Garrison, UT	28	0.040	0.014	0.022
Logan, UT	29	0.017	0.007	0.013
Parowan, UT	21	0.018	0.009	0.014
Vernal, UT	35	0.050	0.011	0.021
Wendover, UT	28	0.029	0.006	0.018
Seattle, WA	37	0.007	0.003	0.005
Spokane, WA	31	0.036	0.004	0.016
Rock Springs, WY	41	0.021	0.012	0.016
Worland, WY	29	0.018	0.009	0.014

[a] 10^{-12} µCi/mL = pCi/m^3; multiply the result by 0.037 to obtain Bq/m^3.

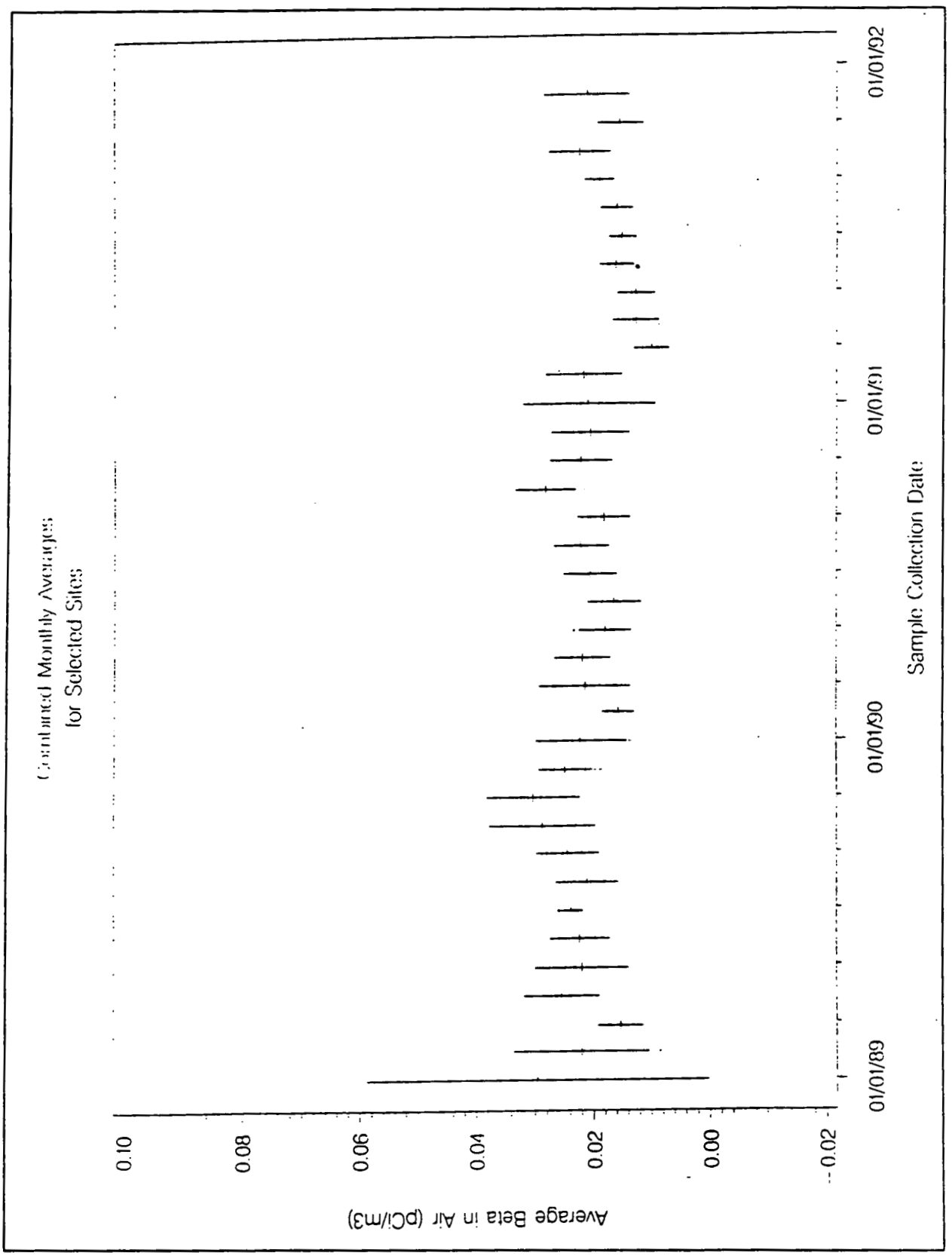

Figure 5.11 Gross Beta Averages For ASN Stations Around the NTS, 1989-91

Valley, Austin, Beatty, Goldfield, Indian Springs, Rachel, and Tonopah, Nevada. The figure indicates little change in regional gross beta activity over the last several years.

In addition to gamma spectroscopy analysis, selected air filters are analyzed for plutonium isotopes. Prefilters from five ASN stations are composited monthly and prefilters from two SASN stations in each of 13 states are composited quarterly and submitted for plutonium analysis. Because Alamo, Nevada is located in the prevailing downwind direction from areas on the NTS undergoing or scheduled for remediation activities, filters from this station were composited for plutonium analysis beginning in January 1991. The remaining four ASN stations for which plutonium analyses were conducted were Salt Lake City, Utah and Las Vegas, Amargosa Valley, and Rachel, Nevada. Beginning on January 1, 1992, plutonium analyses of filters from the Salt Lake City air sampler will no longer be done. In addition to the ASN samplers, high-volume air samplers were installed and operated in Amargosa Valley, Nevada in May 1991 and in Rachel, Nevada from May 28 through July 8, 1991. Filters from these samplers were also analyzed for plutonium isotopes.

Table 5.21 lists plutonium results for the period July 1990 through June 1991. Results for the remainder of 1991 are not yet available due to the length of time required to perform the analysis. Texas third quarter, 1990, and Oregon second quarter, 1990, results were not obtained since samplers were not operated for the required period of time. Six samples exceeded the MDC; four were borderline and the other two were the high-volume samples obtained from Amargosa Valley and Rachel, Nevada. In general, the plutonium activity in the four quarters covered by this report decreased as compared to the period July 1989 through June 1990. Overall, the gamma spectroscopy and plutonium analysis results indicate no airborne radioactivity related to current operations at the NTS was detected on any ASN or SASN sample.

TRITIUM IN ATMOSPHERIC MOISTURE (HTO)

At the beginning of 1991, the tritium network consisted of 20 routinely operated and two standby stations. Figure 4.7 (Chapter 4) depicts the locations of these stations in conjunction with the noble gas sampling network. A number of changes were implemented during 1991, including relocation of the St. George, Utah Community Monitoring Station (CRMS) from the high school to Dixie Junior College on September 4, 1991, discontinuation of the Pioche, Nevada station in November, and installation of a station on Fallini's Ranch

Table 5.21 Plutonium Results for the Air Surveillance Network - 1991

Composite Sampling Location	Collection Date	Concentration ± 1s (MDC)[a] ^{238}Pu x 10^{-18} µCi/mL	Concentration ± 1s (MDC)[a] $^{239+240}Pu$ x 10^{-18} µCi/mL
Arizona (Winslow & Tucson)	09/17/90	4.4 ± 7.7(21)	4.4 ± 9.8(29)
	12/19/90	6.2 ± 11(29)	0 ± 8.8(29)
	02/05/91	-23 ± 14(62)	0 ± 11(36)
	05/06/91	-35 ± 20(95)	-12 ± 20(77)

(a) MDC = minimum detectable concentration.
* Concentration is greater than the MDC.

Table 5.21 (Plutonium Results for the Air Surveillance Network - 1991, cont.)

Composite Sampling Location	Collection Date	Concentration ± 1s (MDC)[a] ^{238}Pu x 10^{-18} µCi/mL	Concentration ± 1s (MDC)[a] $^{239+240}Pu$ x 10^{-18} µCi/mL
California (Bishop & Ridgecrest)	08/09/90	-9.4 ±21(76)	-9.4 ± 9.5(44)
	11/09/90	10 ± 18(49)	10 ± 18(49)
	02/13/91	-12 ± 15(55)	12 ± 12(28)
	05/15/91	0 ± 8.2(27)	0 ± 8.2(27)
Colorado (Denver & Cortez)	08/20/90	33 ± 33(77)	0 ± 23(77)
	11/28/90	0 ± 19(63)	-14 ± 14(63)
	01/25/91	-11 ± 11(50)	11 ± 19(50)
	05/24/91	14 ± 11(22)	-9.6 ± 9.6(39)
Idaho (Nampa & Mountain Home)	07/23/90	14 ± 14(33)	-7.2 ± 7.2(33)
	10/22/90	-19 ± 19(88)	0 ± 27(88)
	01/27/91	-9.4 ± 9.4(44)	-9.4 ± 9.4(44)
	04/24/91	-5.1 ± 8.8(33)	-5.1 ± 5.1(24)
Missouri (Clayton & Joplin)	09/17/90	9.8 ± 17(46)	9.8 ± 17(46)
	11/26/90	-5.2 ± 9.1(35)	5.2 ± 9.1(24)
	01/30/91	7.1 ± 19(57)	14 ± 14(33)
	05/31/91	-4.5 ± 10(36)	9 ± 11(30)
Montana (Great Falls & Miles City)	09/17/90	0 ± 10(33)	7.1 ± 12(33)
	12/28/90	0 ± 9.9(33)	5 ± 8.6(23)
	01/31/91	-17 ± 21(79)	-8.4 ± 8.4(39)
	05/24/91	5.4 ± 9.3(25)	-5.4 ± 5.3(25)
Alamo, Nevada	01/28/91	1.5 ± 3.5(10)	1.5 ± 2.7(7.2)
	02/25/91	-1.5 ± 2.1(7.7)	2.2 ± 2(4.9)
	03/25/91	-5.2 ± 2.6(12)	0 ± 1.8(6.1)
	04/29/91	-0.8 ± 0.8(3.9)	-0.8 ± 1.4(5.5)
	05/27/91	-0.8 ± 0.8(3.9)	0.8 ± 1.4(3.9)
	06/24/91	0 ± 1.8(5.8)	-1.3 ± 1.3(5.8)
Amargosa Valley, Nevada	07/30/90	6.7 ± 12(31)	-6.7 ± 6.8(31)
	08/26/90	0 ± 12(41)	8.8 ± 20(58)
	09/30/90	0 ± 14(47)	-5.8 ± 5.8(27)
	10/28/90		*Sample Lost*
	11/25/90	-9.6 ± 7(63)	9.6 ± 17(45)
	12/30/90	12 ± 8.6(20)	0 ± 4.2(14)
	01/27/91	-3.1 ± 3.1(14)	0 ± 4.4(14)
	02/24/91	2.6 ± 5.8(17)	0 ± 3.7(12)
	03/31/91	-25 ± 19(78)	0 ± 12(39)
	04/28/91	3.9 ± 4.7(13)	1.9 ± 3.4(9)
	05/26/91	-3.4 ± 7.6(27)	3.4 ± 5.9(22)
	05/28/91 *(Hi Vol)*	-0.1 ± 0.1(0.4)	*1.1 ± 0.3(0.4)
	06/30/91	0 ± 3.3(11)	7.1 ± 5.3(11)
Las Vegas, Nevada	07/29/90	-8.8 ± 8.8 (36)	4.4 ± 7.7 (21)
	08/27/90	-5.5 ± 5.5(26)	-5.5 ± 9.5(36)
	09/24/90	-2.8 ± 2.8(13)	2.8 ± 4.8(13)
	10/08/90	1 ± 2.3(6.9)	3.1 ± 0.4(4.9)

(a) MDC = minimum detectable concentration.
* Concentration is greater than the MDC.

Table 5.21 (Plutonium Results for the Air Surveillance Network - 1991, cont.)

Composite Sampling Location	Collection Date	Concentration ± 1s (MDC)[a] ^{238}Pu x 10^{-18} µCi/mL	Concentration ± 1s (MDC)[a] $^{239+240}Pu$ x 10^{-18} µCi/mL
	11/26/90	3.7 ± 4.4(12)	5.5 ± 4.1(8.5)
	12/31/90	*11 ± 5.8(10)	0 ± 3.1(10)
	01/28/91	0 ± 9.2(30)	3.3 ± 5.7(15)
	02/25/91	*17 ± 8.1(16)	0 ± 3.4(11)
	03/25/91	4.2 ± 4.2(9.8)	0 ± 3(9.8)
	04/29/91	-1:8 ± 4.1(15)	1.8 ± 4.1(12)
	05/27/91	-2.5 ± 2.5(12)	-2.5 ± 2.5(12)
	06/24/91	10 ± 6.2(12)	-2.5 ± 5.6(20)
Rachel,Nevada	07/29/90	-8 ± 18(64)	-8 ± 8(37)
	08/26/90	-5.9 ± 5.9(28)	0 ± 8.4(28)
	09/23/90	6.7 ± 6.7(16)	0 ± 4.7(16)
	10/28/90	-3.5 ± 3.5(16)	0 ± 5(16)
	11/25/90	1.9 ± 3.3(8.8)	3.8 ± 3.8(8.8)
	12/25/90	1.7 ± 2.9(7.8)	0 ± 2.4(7.8)
	01/28/91	-2.6 ± 2.6(12)	0 ± 3.6(12)
	02/25/91	7.8 ± 6.2(16)	-2 ± 2(9.1)
	03/25/91	-3 ± 2.3(9.4)	1 ± 1.7(4.7)
	04/29/91	4.3 ± 3.2(6.6)	-4.3 ± 2.5(11)
	05/28/91	0 ± 4.1(13)	4.1 ± 4.1(9.5)
	06/24/91	-3 ± 6.8(25)	0 ± 6.1(20)
	07/08/91 *(HiVol)*	0.3 ± 0.3(0.6)	*7.4 ± 1.1(0.6)
New Mexico (Albuquerque & Carlsbad)	09/17/90	12 ± 21(56)	-12 ± 12(56)
	11/26/90	-6.8 ± 6.8(32)	6.8 ± 12(32)
	03/22/91	-8.4 ± 6.3(26)	0 ± 3.9(13)
	06/28/91	35 ± 22(41)	-27 ± 15(71)
North Dakota (Bismarck & Fargo)	09/24/90	0 ± 20(65)	0 ± 20(65)
	11/26/90	-3.8 ± 3.8(18)	3.8 ± 3.8(18)
	03/12/91	5.9 ± 13(39)	12 ± 12(28)
	06/27/91	0 ± 7.7(26)	7.8 ± 7.8(18)
Oregon (Burns & Medford)	09/21/90	41 ± 25(48)	10 ± 24(67)
	12/03/90	0 ± 12(40)	24 ± 15(28)
	02/11/91	-12 ± 8.4(39)	0 ± 8.4(28)
Texas (Austin & Amarillo)	11/28/90	0 ± 13(44)	*33 ± 18(31)
	03/15/91	-3.2 ± 5.5(21)	-3.2 ± 3.2(15)
	06/28/91	10 ± 17(47)	0 ± 14(47)
Utah (Logan & Vernal)	09/18/90	21 ± 21(49)	0 ± 21(69)
	12/31/90	6.8 ± 12(32)	0 ± 9.6(32)
	03/11/91	-15 ± 12(48)	-5.1 ± 5.2(24)
	06/27/91	*21 ± 11(19)	-8.3 ± 8.3(34)
Salt Lake City, Utah	07/30/90	-12 ± 12(55)	12 ± 20(55)
	08/27/90	13 ± 13(31)	6.5 ± 11(31)
	09/24/90	5.9 ± 5.9(14)	-5.9 ± 4.2(20)
	10/29/90	-1.8 ± 3(12)	5.2 ± 3.9(8.1)

(a) MDC = minimum detectable concentration.
* Concentration is greater than the MDC.

Table 5.21 (Plutonium Results for the Air Surveillance Network - 1991, cont.)

Composite Sampling Location	Collection Date	Concentration ± 1s (MDC)[a] ^{238}Pu x 10^{-18} µCi/mL	Concentration ± 1s (MDC)[a] $^{239+240}Pu$ x 10^{-18} µCi/mL
	11/26/90	-2.9 ± 5.1(19)	8.8 ± 6.6(14)
	12/31/90	0 ± 2.3(7.6)	0 ± 2.3(7.6)
	01/28/91	3.7 ± 5.2(15)	0 ± 2.6(8.6)
	02/25/91	-1.1 ± 2.8(9.9)	0 ± 1.5(5)
	03/25/91	-2 ± 2(9.1)	0 ± 2.8(9.1)
	04/29/91	0 ± 2.5(8.1)	0 ± 2.5(8.1)
	05/31/91	2.9 ± 5(13)	-5.7 ± 5.8(23)
	06/28/91	0 ± 4.1(14)	2.1 ± 3.6(9.6)
Washington (Seattle & Spokane)	09/24/90	15 ± 26(70)	15 ± 26(70)
	11/28/90	7.2 ± 7.2(17)	3.6 ± 6.3(17)
	03/22/91	-5.5 ± 9.5(36)	-5.5 ± 5.5(26)
	06/29/91	70 ± 44(82)	0 ± 41(142)
Wyoming (Worland & Rock Springs)	09/27/90	-4.8 ± 11(39)	4.8 ± 8.4(23)
	11/27/90	17 ± 30(114)	0 ± 24(81)
	03/30/91	8.7 ± 20(57)	8.7±15(41)
	05/13/91	8.1 ± 18(53)	8.1 ± 14(38)

(a) MDC = minimum detectable concentration.
• Concentration is greater than the MDC.

(Twin Springs, Nevada). In November, the following six stations were converted from routine to standby status (date of last sample collection shown in parentheses): Salt Lake City, Utah (Nov. 1), Shoshone, California and Ely, Nevada (Nov. 12), Austin, Nevada and Cedar City, Utah (Nov. 13), and Caliente, Nevada (Nov. 14). In addition, the two standby stations in Utah (Milford and Delta) were not activated at any time during 1991.

Of the 957 samples analyzed in 1991, 23 were of insufficient volume to permit analysis and six exceeded the MDC. Of these six samples, three were borderline. One of these was the sample collected March 11 through 18, 1991 at the Salt Lake City, Utah station. This station is located adjacent to the engineering complex housing a nuclear reactor. Two samples from the Las Vegas, Nevada station yielded results greater than the MDC; these two were collected June 24 through July 1, 1991 and July 19 through 22, 1991. This station is located near the EPA Radioanalysis Laboratory. The average HTO concentration for the Las Vegas, Nevada station was 1.69 x 10^{-6}pCi/mL in 1991; the average for that location in 1990 was 4.2 x 10^{-7} pCi/mL. The overall network HTO average for 1991 was 5.0 x 10^{-7} pCi/mL compared to a network average of 5.9 x 10^{-7} pCi/mL in 1990. Summary data results are given in Table 5.22.

Table 5.22 Atmospheric Tritium Results, 1991

Sampling Location	Number of Samples Analyzed	Concentration 10^{-6}pCi/mL[a]			Percent of the Concentration Guide[b]
		Maximum	Minimum	Average	
Shoshone, CA	45	2.9	-4.6	0.12	<0.01
Alamo, NV	52	7.2	-4.3	0.79	<0.01
Amargosa Valley Community Ctr, NV	51	6.1	9.2	0.47	<0.01
Austin, NV	46	4.0	-2.0	0.50	<0.01
Beatty, NV	51	3.8	-1.0	0.60	<0.01
Caliente, NV	46	9.7	-10.2	0.42	<0.01
Ely, NV	45	4.4	-34.2	-0.27	<0.01
Goldfield, NV	53	14.3	-7.0	0.42	<0.01
Indian Springs, NV	48	9.2	-3.7	0.86	<0.01
Las Vegas, NV	53	*15.0(10.8)	-2.9	1.69	<0.01
Amargosa Valley, NV	49	2.7	-3.0	0.27	<0.01
Overton, NV	53	2.8	-3.9	0.40	<0.01
Pahrump, NV	52	5.9	-3.0	0.26	<0.01
Pioche, NV	46	8.4	-3.1	0.61	<0.01
Rachel, NV	50	*2.4(2.2)	-4.6	0.40	<0.01
Tonopah, NV	52	11.6	-6.1	0.79	<0.01
Twin Springs, NV Fallini's Ranch	6	2.2	-1.6	0.14	<0.01
Cedar City, UT	45	3.9	-7.0	0.11	<0.01
St. George, UT	51	5.2	-2.6	0.36	<0.01
Salt Lake City, UT	41	*10.2(4.0)	-3.3	0.97	<0.01

(a) 10^{-6} pCi/mL = pCi/m^3; multiply the result by 0.037 to obtain Bq/m^3. Concentrations exceeding the minimum detectable concentration (MDC) are preceded by * and in these instances, the MDC value is specified in parenthesis after the maximum concentration value.

(b) The concentration guide referenced is calculated from the dose conversion factors for inhalation as listed in DOE Order 5400.5, adjusting to 10 mrem effective dose equivalent as required by 40 CFR 61 for nonoccupational exposure to radionuclides in air.

NOBLE GAS SAMPLING NETWORK

At the beginning of 1991, the Noble Gas Sampling Network consisted of 16 routinely operated and three standby stations. Noble gas samplers were added to the Amargosa Valley Community Center and to the Twin Springs, NV (Fallinis' Ranch), Station in May of 1991, increasing the number of routinely operated stations to 18. Samples were collected approximately once a week from the routinely operated stations and between 1 and 4 times during the year from the standby stations. Samples were analyzed for ^{85}Kr and ^{133}Xe. The locations of the Noble Gas sampling stations are shown in Figure 4.7 (Chapter 4).

Noble gases may be released into the atmosphere from research and power reactor facilities, fuel reprocessing facilities, and from nuclear testing. Environmental levels of the xenons, with their very short half-lives, are normally below the MDC. ^{85}Kr disperses more or less uniformly over the entire globe because of its half-life, 10.7 years, and the lack of significant sinks (NCRP44 1975). For these reasons, ^{85}Kr results are expected to be above MDC.

A number of changes were made to the network during 1991 in addition to installing noble gas samplers at two stations. In November, the following five stations were converted from routine to standby status: Austin, Caliente, and Ely, NV; Shoshone, CA; and Cedar City, UT. All of the existing noble gas samplers, used since 1974, were replaced with newly designed samplers during 1991. The first replacement was completed at the Las Vegas station in March. After a successful evaluation period, replacement was initiated at the remaining stations in May. An essential part of the development included comparison testing of the old and new model systems to ensure data comparability.

Table 5.23 summarizes the ^{85}Kr and ^{133}Xe results for all routine and standby sampling locations. These tables contain the number of samples analyzed and the minimum, maximum, average, and standard deviation of the concentrations measured at each station. The number of samples analyzed is frequently less than 52 because samples are occasionally lost in analysis, lost due to equipment failure, or the sample volume collected is insufficient to permit analysis. Some of the data losses were due to problems experienced with the new noble gas samplers. These problems are discussed further in Chapter 12. All of the ^{85}Kr results exceeded the MDC and were within the range anticipated. Activities ranged from 20.5 to 32.3 x 10^{-12} μCi/ml. This activity range is virtually identical to that observed in 1990. All of the ^{133}Xe results were below the MDC. The MDC for ^{133}Xe varied but was generally about 14 pCi/m^3.

Figure 5.12 shows the distribution of the ^{85}Kr data from each routine sampling location arranged by ascending means. Those stations for which the status changed from routine to standby in November are included in the graph as they were routinely sampled throughout the majority of the year. The bottom and top edges of the box on the graph represent the 25th and 75th percentiles of the distribution of the data (i.e., 50% of the data falls within this region). The short, vertical line drawn inside the box represents the 50th percentile or the median value. The horizontal lines extend from the box to the minimum and maximum values. The filled circle represents the mean. The graph shows that ^{85}Kr results are very consistent among stations. The results for ^{133}Xe are not graphed as all the values were below the MDC.

Table 5.23 Noble Gas Sampling Network - ^{85}Kr and ^{133}Xe Results, 1991

Kr-85 Concentration ($10^{-12}\mu Ci/mL$ = pCi/m3)

Station Name	No. of Samples	Minimum	Maximum	Average	Standard Deviation
Alamo, NV	44	22.4	30.7	26.3	1.99
Amargosa Center, NV	24[a]	24.0	31.0	27.5	2.16
Amargosa Valley, NV	42	23.5	30.2	26.6	1.73
Austin, NV	32[b]	22.3	30.9	26.5	2.25
Beatty, NV	52	22.2	30.9	26.3	1.92
Caliente, NV	37[b]	21.9	29.7	25.8	1.85
Cedar City, UT	33[b]	22.4	29.2	26.0	1.82
Delta, UT	4[c]	25.0	30.0	27.3	1.92
Ely, NV	38[b]	21.3	31.1	26.3	2.03
Goldfield, NV	51	22.6	31.1	27.0	1.96
Indian Springs, NV	48	20.8	31.0	26.8	2.02
Las Vegas, NV	45	22.3	31.0	26.8	1.98
Milford, UT	3[c]	22.5	28.3	26.2	3.19
Overton, NV	53	21.2	32.3	26.4	2.08
Pahrump, NV	46	21.3	30.7	26.5	2.14
Rachel, NV	45	21.6	30.5	26.8	1.95
Salt Lake City, UT	1[c]	23.8	23.8	23.8	N/A
Shoshone, CA	38[b]	20.5	28.9	25.9	2.00
St. George, UT	46	21.1	30.2	26.2	2.26
Tonopah, NV	46	20.9	30.6	26.2	2.15
Twin Springs, NV	28[a]	21.5	30.1	26.8	1.90

Xe-133 Concentration ($10^{-12}\mu Ci/mL$ = pCi/m3)

Alamo, NV	45	-12.40	12.70	-1.14	5.65
Amargosa Center, NV	26[a]	-13.00	16.00	-2.37	6.51
Amargosa Valley, NV	41	- 7.29	4.10	-1.36	3.03
Austin, NV	32[b]	-19.20	9.50	-2.06	6.02
Beatty, NV	52	-13.60	7.06	-0.88	4.33
Caliente, NV	37[b]	-20.90	13.40	-2.51	7.21
Cedar City, UT	33[b]	-13.90	5.52	-2.23	4.97
Delta, UT	4[c]	6.2	10.0	8.50	1.46
Ely, NV	38[b]	-18.90	12.40	-1.39	6.64
Goldfield, NV	51	-11.40	9.75	-0.86	4.26
Indian Springs, NV	49	- 6.88	5.29	-0.64	3.12
Las Vegas, NV	47	- 7.55	13.90	-0.84	3.71
Milford, UT	3[c]	- 6.68	8.93	-1.15	8.74
Overton, NV	53	- 9.70	13.40	-1.48	4.30
Pahrump, NV	47	- 7.88	4.30	-1.42	3.14
Rachel, NV	46	-15.00	15.00	-1.08	5.72
Salt Lake City, UT	1[c]	- 1.63	-1.63	-1.63	N/A
Shoshone, CA	39[b]	- 9.18	3.81	-1.48	3.44
St. George, UT	49	-12.40	14.40	-2.16	4.49
Tonopah, NV	46	-13.80	7.20	-1.41	4.64
Twin Springs, NV	27[a]	-15.30	5.91	-2.56	5.72

a Installed in May, 1991
b Standby status as of November, 1991
c Standby Stations

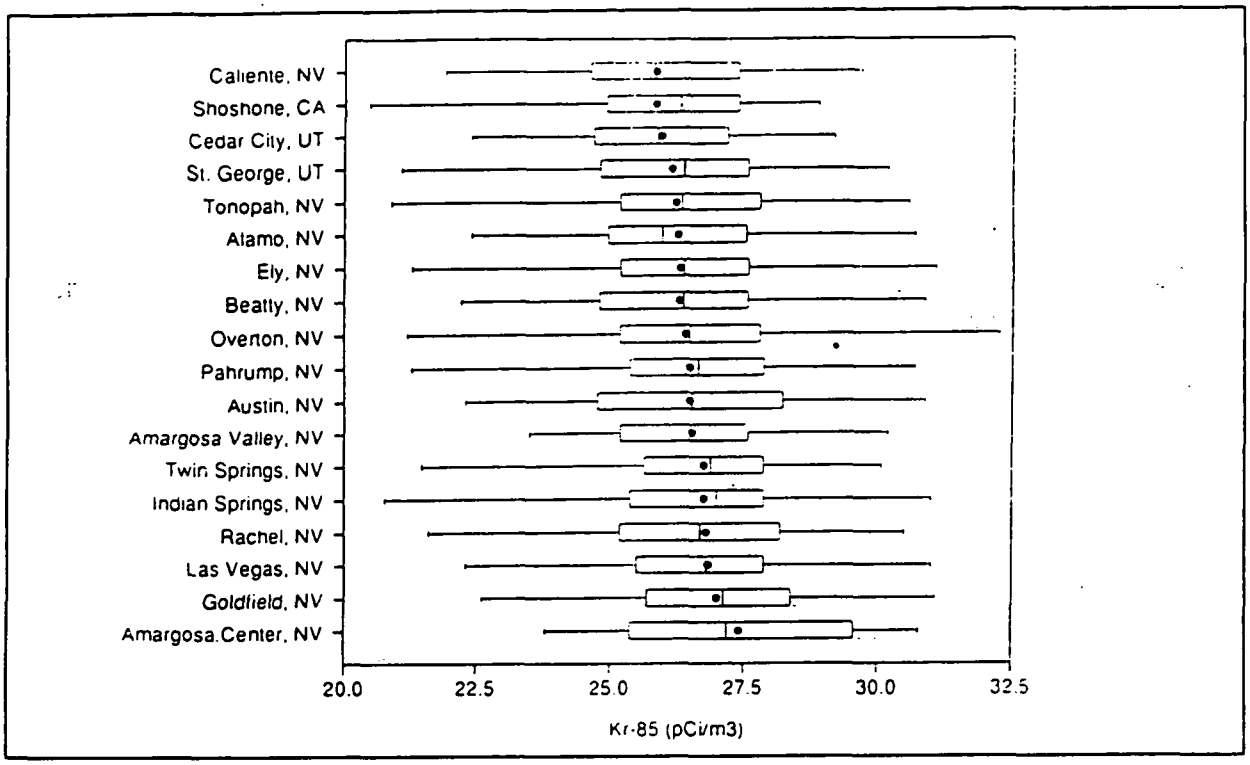

Figure 5.12 Distribution of Krypton-85 results from each Sampling Location - 1991

5.2.2.2 WATER MONITORING

Environmental surveillance of water in the offsite areas around the NTS is conducted as part of the Long-Term Hydrological Monitoring Program (LTHMP). Samples are collected from wells and, in a few instances, surface water sources on the NTS and in the offsite areas. All results for the LTHMP are discussed in Chapter 9, "Groundwater Monitoring."

5.2.2.3 BIOMONITORING

Sites where animals were collected in late 1990 and 1991 are shown in Chapter 4, Figure 4.10. Each year, the animals collected include one mule deer collected each quarter on the NTS, four cattle purchased in the fall and another four purchased in the spring from ranches in the vicinity of the NTS, and bighorn sheep bones and kidneys donated by hunters during the winter hunting season. Occasionally, other animals become available; this was the case in 1991 as a mountain lion was obtained by hunting on the NTS. The lion had been menacing the Area 12 camp, necessitating its elimination. In addition to animals, locally grown fruits and vegetables are obtained by donation from local residents.

BIGHORN SHEEP

Nevada hunters are asked to voluntarily donate one leg bone and one kidney from bighorn sheep obtained during the winter hunting period. The sheep hunt takes place in November and December, hence, the data presented here are from animals hunted in late 1990. From the donated samples, a subset was selected representing areas around the NTS. The kidney samples were analyzed for gamma-emitting radionuclides and for tritium. The bone samples were ashed prior to analysis of ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$. The results obtained from analysis of bighorn sheep bone and kidney are shown in Table 5.24. The numbers in the first column of the table refer to the numbered sample locations shown in Figure 4.10 (Chapter 4). Other than naturally occurring ^{40}K, gamma-emitting radionuclides were not detected, nor was tritium detected, at activities greater than the MDC in any of the kidney samples. All of the bone tissue samples, however, yielded ^{90}Sr activities greater than the MDC of the analysis. The range and median values for ^{90}Sr, shown in Table 5.24 and in Table 5.25, were similar to those obtained last year (DOE, 1991). The average ^{90}Sr levels found in animal bone ash

Table 5.24 Radionuclide Concentrations in Desert Bighorn Sheep Samples taken in Winter - 1990

Bighorn Sheep (Collected in the Winter of 1990)	Percent Ash	Bone ^{90}Sr Concentration ± 1 σ (pCi/g Ash)	Bone ^{238}Pu Concentration ±1 σ (10^{-3}pCi/g Ash)[b]	Bone $^{239+240}Pu$ Concentration ± 1 σ (10^{-3}pCi/g Ash)[b]	Kidney[a] ^{3}H Concentration ± 1 σ (pCi/L)(c)
1	33	*1.8 ± 0.1	-1.3 ± 0.9	0.7 ± 1.5	-50 ± 140
2	34	*1.7 ± 0.1	-0.00004 ± 0.6	0.4 ± 0.7	130 ± 140
3	32	*2.0 ± 0.2	-1.3 ± 1.8	0.6 ± 1.4	-30 ± 140
4	27	*1.2 ± 0.2	1.0 ± 1.3	-0.0001 ± 1.1	30 ± 140
5	30	*2.0 ± 0.2	-0.4 ± 0.4	*4.5 ± 1.6	220 ± 140
6	36	*0.5 ± 0.1	-0.0001 ± 1.1	-1.0 ± 0.8	100 ± 140
7	33	*1.1 ± 0.1	0.6 ± 2.1	-0.6 ± 1.1	170 ± 140
8	34	*1.4 ± 0.1	0.7 ± 1.7	0.7 ± 1.7	-80 ± 140
9	32	*1.2 ± 0.1	-1.1 ± 1.1	4.5 ± 2.8	60 ± 140
10	36	*1.0 ± 0.1	0.8 ± 1.0	-0.4 ± 0.7	110 ± 140
11	34	*1.2 ± 0.1	-0.4 ± 0.4	-0.4 ± 0.4	-10 ± 140
12	35	*1.8 ± 0.1	-0.6 ± 1.8	-0.6 ± 1.0	-50 ± 140
13	34	*1.7 ± 0.1	-0.0001 ± 1.0	2.5 ± 1.5	NC
14	Bone sample not collected				-30 ± 140
15	Bone sample not collected				-10 ± 140
16	Bone sample not collected				150 ± 140
Median	34	1.4	-0.0001	0.4	30
Range	27 - 36	0.5 - 2.0	-1.3 - 1.0	-1.0 - 4.5	-80 - 220

[a] Aqueous portion of the kidney tissue.
[b] To convert pCi/g to Bq/kg divide the concentration by 0.027.
[c] To convert pCi/L to Bq/L divide the concentration by 27.
NC Not collected.
* greater than minimum detectable concentration.

Table 5.25 Radiochemical Results for Animal Samples - 1991

Sample	Number of Samples	% ash Median Range	^{90}Sr Median Range (pCi/g)	^{238}Pu Median Range (x 10^{-3}pCi/g ash)	$^{239+240}Pu$ Median Range (x 10^{-3}pCi/g ash)	Median Range (^{3}H pCi/L)
Cattle Blood	8					241 (120 to 360)
Cattle Liver	8	1.3 (1.0 - 1.4)		2.4 (-0.0001 - 60)	35 (-0.0001 - 3400)	
Deer Muscle	4	1.0 (1.0 to 1.1)		7.2 (-1.1 - 18)	402 (-0.7 - 1200)	
Deer Lung	4	1.0 (0.9 - 1.0)		1.3 (-17 - 10)	10.7 (-0.8 - 350)	
Deer Liver	4	1.3 (0.9 - 1.4)		2.4 (0.7 - 6.0)	5.2 (2.2 - 170)	
Deer Rumen Content	4	3.9 (1.7 - 21)		5.0 (2.0 - 12)	73 (17 - 110)	
Deer Blood	4				504 (-28 - 420,000)	
Deer Bone	4	33 (30 - 35)	0.7 (0.5 - 0.9)	0.5 (-0.7 - 2.1)	0.7 (-0.0002 - 5.9)	
Cattle Bone	8	34 (19 - 47)	0.8 (0.3 - 1.3)	-0.5 (-3.1 - 0.7)	0.0 (-0.7 - 5.1)	
Sheep Bone	13	34 (27 - 26)	1.4 (0.5 - 2.0)	-0.0001 (-1.3 - 1.0)	0.4 (-1.0 - 4.5)	
Sheep Kidney	15					30 (-80 - 220)
Mt. Lion Muscle	1	1.2		-3.0	18	
Mt. Lion Bone	1	20	1.1	-3.3	2.6	
Mt. Lion Blood	1					71,300

since 1955 are shown in Figure 5.13. None of the bone samples yielded ^{238}Pu results greater than the MDC of the analysis and only one sample (Bighorn sheep No. 5) yielded a $^{239+240}Pu$ result greater than the MDC. This animal was collected in Area 287, south of Searchlight, Nevada. Medians and ranges of plutonium isotopes, given in Table 5.24 and in Table 5.25, were similar to those obtained in the previous year (DOE, 1991).

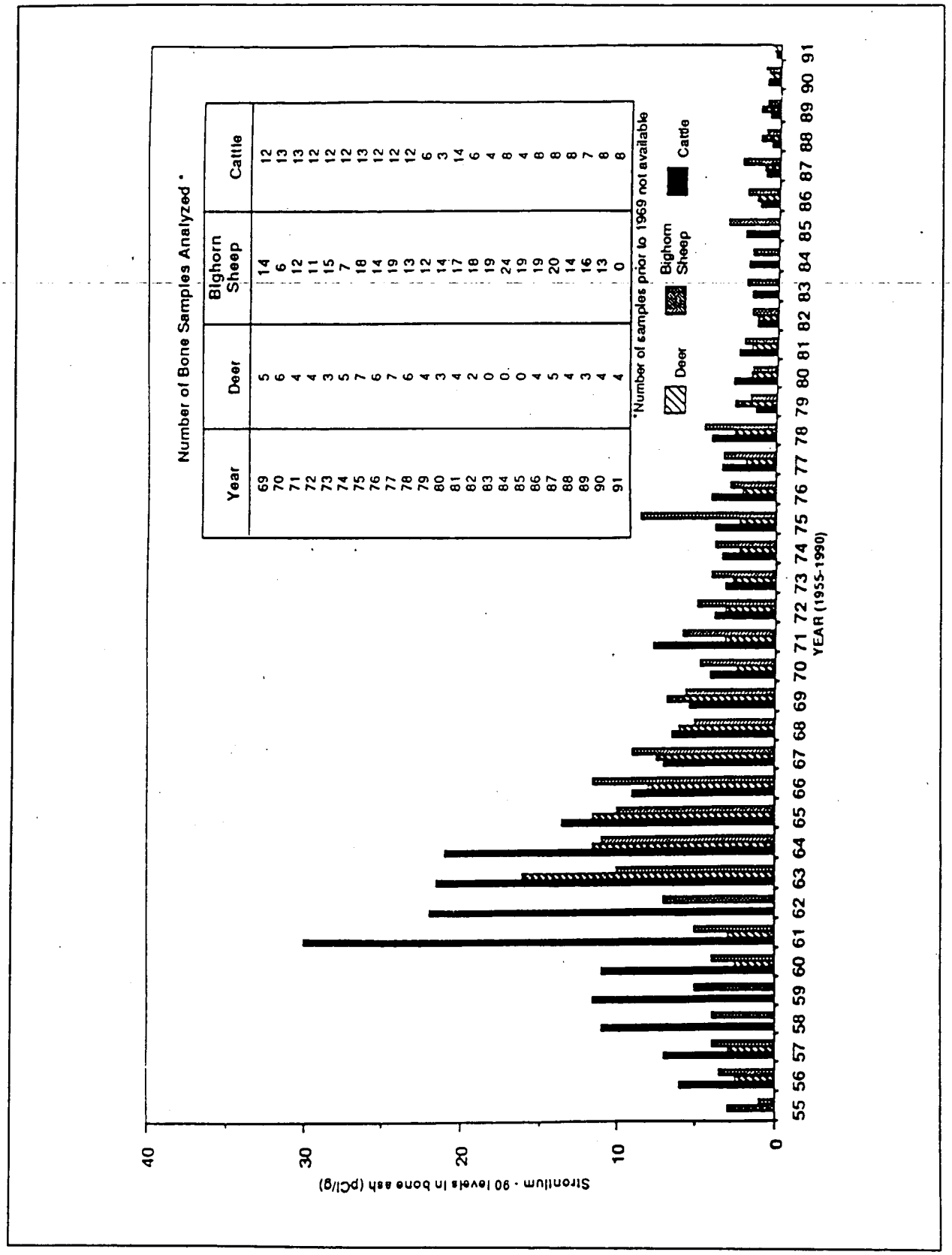

Figure 5.13 Average ^{90}Sr Levels in Animal Bone Ash 1955 - 91

MULE DEER

One mule deer was obtained, either by hunting or road kill, each quarter from areas on the NTS. Blood samples were analyzed for gamma-emitting radionuclides and tritium. Soft tissue samples (lung, muscle, liver, thyroid, rumen contents, and fetus, when available) were analyzed for gamma-emitting radionuclides. Additionally, samples of soft tissues and bones were ashed and then analyzed for plutonium isotopes; ashed bone samples were also analyzed for ^{90}Sr. Samples of thyroid and fetal tissue are not ashed due to their small size.

The mule deer collected in the first quarter of 1991 was a pregnant female in poor condition obtained by hunting in Area 12. Analysis of blood, soft tissue, and bone samples indicated the animal had been contaminated by radioactivity. No gamma-emitting radionuclides other than naturally occurring ^{40}K were detected in soft tissues, however, $^{239+240}Pu$ was detected in all of the ashed soft tissue samples, ranging from 0.008 ± 0.003 pCi/g ash in the liver sample to 1.2 ± 0.1 pCi/g ash in the muscle sample. Concentrations of ^{238}Pu greater than the MDC of the analysis were also obtained in the lung and rumen contents samples. The bone sample also yielded 0.9 ± 0.2 pCi/g ash of ^{90}Sr. The tritium activity in the blood sample was 420,000 ± 1000 pCi/L, indicating the animal probably drank from the Area 12 containment ponds.

The mule deer collected in the second quarter also showed indications of contamination. This animal was a road kill in the southeast portion of the NTS (see Figure 4.10 in Chapter 4). Although the blood sample was negative for tritium and no gamma-emitting radionuclides other than ^{40}K were found in the soft tissue samples, all of the ashed soft tissue samples contained $^{239+240}Pu$ at concentrations greater than the MDC of the analysis. The $^{239+240}Pu$ activities in ashed soft tissues ranged from 0.09 ± 0.01 pCi/g ash in the rumen contents to 0.8 ± 0.1 pCi/g ash in the muscle sample. In addition, ^{238}Pu was detected at activities greater than the MDC of the analysis in the lung and liver samples. The bone sample results were less than the analysis MDC for plutonium isotopes and 0.5 ± 0.1 pCi/g ash for ^{90}Sr.

The other two mule deer, obtained in the third and fourth quarters of 1991, yielded results less than the analysis MDC for most analyses, with the exceptions of a tritium activity of 1000 ± 150 pCi/L in the blood sample from mule deer No. 3, a ^{238}Pu activity of 0.012 ± 0.002 pCi/g ash in the rumen contents of mule deer No. 4, and greater-than-MDC $^{239+240}Pu$ activities in the rumen contents of both animals. Mule deer No. 3 was collected in Area 12, and so could possibly have drunk from the Area 12 containment ponds. Mule deer No. 4 was obtained near Echo Peak on the NTS.

The medians and ranges of the 1991 mule deer analyses, presented in Table 5.25, are similar to those reported for mule deer collected in 1990 for bone tissue analyses and ^{238}Pu analyses in all tissues. The average ^{90}Sr levels found in animal bone ash since 1955 are shown in Figure 5.13. Marked differences between years are observed in the medians of tritium activity in blood and $^{239+240}Pu$ in ashed soft tissues. These differences are due to the fact that two contaminated animals were collected in 1991. In past years, none or, at most, one of the mule deer have shown evidence of radioactive contamination and, thus, a contaminated sample had no impact on the median.

CATTLE

Four cattle were purchased from the Courtney Dahl ranch in Delamar Valley (near Alamo, Nevada) in the spring of 1991 and another four were purchased from the William Agee ranch near Rachel, Nevada in the fall of 1991. Both adult and juvenile cows were purchased. The animals were slaughtered at the EPA farm facility on the NTS. Blood and soft tissues (lung,

muscle, liver, thyroid, and kidney) were analyzed for gamma-emitting radionuclides; blood was also analyzed for tritium activity. Samples of kidney and bone were ashed and analyzed for plutonium isotopes; bone samples were also analyzed for ^{90}Sr. Duplicate kidney and bone samples from one cow in each group of four were prepared and analyzed.

All four of the cows purchased from the Courtney Dahl ranch yielded detectable concentrations of ^{90}Sr in bone ash samples, ranging from 0.29 ± 0.04 pCi/g ash to 1.00 ± 0.07 pCi/g ash. None of the four cows purchased from the William Agee ranch yielded concentrations of ^{90}Sr greater than the MDC; however, the MDC of the analysis was higher for these analyses (approximately 1.4 pCi/g ash as compared to approximately 0.13 pCi/g ash for the spring samples). The average ^{90}Sr levels found in animal bone ash since 1955 are shown in Figure 5.13. All of the liver ash samples, with the exception of the sample from Bovine No. 4, yielded greater-than-MDC concentrations of $^{239+240}Pu$, ranging from 0.015 ± 0.007 pCi/g ash to 3.4 ± 0.2 pCi/g ash.[1] Bovine No. 4 was a young calf, approximately seven months in age. Studies of humans indicate plutonium may bioaccumulate in the liver (NEA, 1981); a similar bioaccumulation process probably takes place in cattle. The only bone ash sample with a $^{239+240}Pu$ result greater than the MDC of the analysis was in the sample from Bovine No. 6, with a value of 0.005 ± 0.002 pCi/g ash.

Medians and ranges, given in Table 5.25, are similar to those reported for animals collected in 1990 (DOE, 1991), with the exception of cattle liver. The 1991 cattle liver median is greater than the upper end of the range in 1990. An investigation was conducted of all procedures from sampling through data reporting. No evidence of uniform contamination could be found, either in sample preparation or analysis. Results of quality assurance/quality control samples analyzed with the animal tissue samples were within specified control limits, with the exception of the duplicate pair discussed in the preceding footnote. The possibility of sample contamination occurring during the ashing process could not be ruled out, although other tissues and mule deer samples submitted for ashing in the same batch yielded results similar to those obtained in previous years, and any source of contamination would have to have affected two different batches of cattle samples submitted at different times. Prior to 1991, plutonium analyses of ashed tissue samples were completed by a contract laboratory. Analysis of samples collected in 1991 was completed by the EPA EMSL-LV Radioanalysis Laboratory. Although the methods used by the two laboratories are similar and should produce comparable data, the possibility of laboratory bias cannot be eliminated. This possibility is unlikely, however, since medians and ranges for other tissues and other animal types were similar for 1990 and 1991 data.

MOUNTAIN LION

A mountain lion which had been menacing the Area 12 camp was killed by an NTS-authorized hunter in the spring of 1991. Kidney, lung, muscle, blood, and liver samples were analyzed for gamma-emitting radionuclides; only naturally occurring ^{40}K was detected. A blood sample analyzed for tritium activity yielded a result of 71,300 ± 400 pCi/L, indicating the animal

[1] The highest result obtained in Bovine No. 2, 3.4 pCi/g ash, is suspect. A duplicate sample prepared from the same liver yielded a greater-than-MDC result of 0.04 ± 0.01 pCi/g ash for $^{239+240}Pu$. Additionally, this sample yielded the only ^{238}Pu result greater than the MDC of the analysis, a result of 0.059 ± 0.007 pCi/g ash, while the duplicate sample ^{238}Pu result was less than the MDC. Repeated analyses yielded similar results. However, an investigation of the sample could not identify a source of contamination. Additionally, the possibility of differing activities in separate liver lobes could not be ruled out as a possible explanation for the observed difference in analytical results. Therefore, the value cannot be invalidated, but should be regarded as suspect.

probably drank from the Area 12 ponds. Muscle and bone samples were ashed and analyzed for plutonium isotopes; the bone sample was also analyzed for ^{90}Sr. Results are given in Table 5.25. The only results greater than the MDC of the analysis were ^{90}Sr in bone, with a result of 1.09 ± 0.07 pCi/g ash, and $^{239+240}Pu$ in muscle, with a result of 0.018 ± 0.009 pCi/g ash.

FRUITS AND VEGETABLES

In the fall of 1991, fifteen samples of locally grown fruits and vegetables were donated by offsite residents in Utah, Arizona, and Nevada. Fruits and vegetables sampled included cabbage, cantaloupes, zucchini and summer squash, onions, carrots, beets, and potatoes. All samples were analyzed for gamma-emitting radionuclides and only naturally occurring ^{40}K was detected. All samples were also analyzed for tritium; no results greater than the MDC of the analysis were obtained. Samples were then ashed and analyzed for ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$. None of the ^{90}Sr results were greater than the MDC of the analysis. Concentrations of ^{238}Pu greater than the analysis MDC were found in two samples, both from Fallis Ranch near Rachel, Nevada, and concentrations of $^{239+240}Pu$ greater than the analysis MDC were found in seven samples. These results are given in Table 5.26. No consistent correlations of greater-than-MDC results with sample location or with vegetable mode of growth (i.e., surface crops as opposed to root crops) were evident.

Table 5.26 Detectable Plutonium Concentrations in Vegetables - 1991

Vegetable	Collection Location	$^{239-240}Pu \pm \sigma$ (pCi/g) ash	$^{239-240}Pu$ MDC[a]	$^{238}Pu \pm \sigma$ (pCi/g) ash	^{238}Pu MDC[a]
Onions	Beaver Dam, AZ (Meddibow Farms)	0.004 ± 0.002	0.002		
Zucchini Squash	Enterprise, UT (Deward Terry)	0.006 ± 0.003	0.005		
Summer Squash (Yellow)	Rachel, NV (Fallis Ranch)	0.029 ± 0.006	0.005	0.008 ± 0.003	0.005
Summer Squash	Rachel, NV (Penoyer Farms)	0.010 ± 0.005	0.008		
Potatoes	Rachel, NV (Fallis Ranch)	0.051 ± 0.005	0.002	0.008 ± 0.002	0.003
Beets	Rachel, NV (Penoyer Farms)	0.007 ± 0.003	0.005		
Red and Green Cabbage	St. George, UT (Jeff Layne)	0.002 ± 0.001	0.002		

[a]MDC = minimum detectable concentration

5.2.2.4 THERMOLUMINESCENT DOSIMETRY NETWORK

During 1991, a total of 131 offsite stations and 72 residents were monitored by the Thermoluminescent Dosimetry (TLD) Network. A small portion of the 1991 TLD data is not included in this report due to a problem with the network software. The network software problem only affects the ability to retrieve data, not the quality of the data. The measurement

period dates given in the tables in this section indicate which data are not included. The 1992 report will include all 1991 data that are not presented in this report.

The primary function of the fixed environmental station TLDs is to characterize ambient background gamma radiation fields. The practice of subtracting reference background readings from fixed environmental station results is valid only to evaluate whether a single measurement varies by a significant amount from the historical record for that location.

Annual exposures measured at fixed environmental stations during 1991 ranged from 47 to 377 mR, with a median of 87 mR. Table 5.27 summarizes the results obtained at each of the fixed environmental stations monitored with TLDs. During 1991, the maximum net annual exposure of 377 mR was measured at Warm Springs, Nevada, located on Highway 6 east of Tonopah. This exposure, at Warm Springs #2, has been consistently high as explained earlier (EPA 1990). Radiation levels measured in a nearby parking lot (Warm Springs #1) indicated an annual net exposure of 116 mR. These values represent gross ambient gamma radiation levels measured at the respective locations.

Figure 5.14 shows 10 years of TLD exposure data expressed as annual means of all stations. The range of exposures observed at fixed environmental monitoring locations during 1991 was virtually the same as that observed in the previous ten years. The range of exposures observed in 1991 was consistent with that expected from background radiation in the United States with the exception of Warm Springs #2, discussed above.

For each resident participating in the TLD Network, the measured exposure can be compared to an associated reference background. An average for all offsite station TLDs is not an appropriate reference background because environmental ambient radiation levels vary markedly with natural radioactivity in the soil, with altitude, and with other factors. Therefore, results obtained at the fixed environmental station closest to that individual are the most appropriate reference point.

Of the 72 individuals monitored, 52 (73.2%) received exposures varying from the associated reference background location by less than 20 mR in one year. Sixty-eight of the 72 (94.4%) received exposures varying from associated reference background by less than 50 mR in one year. In no case did any individual or cumulative exposure exceed regulatory or ALARA investigation limits. The distribution of personnel exposures as compared to associated reference background exposures is shown in Figure 5.15. Table 5.28 summarizes the results of offsite personnel TLD monitoring for 1991. Annual equivalent doses ranged from 31 mrem in an individual from St. George, Utah to 167 mrem in an individual from Stone Cabin Ranch, Nevada. The median value was 76. Absorbed radiation dose to personnel is calculated at three depths in tissue 17mg/cm^2, 300mg/cm^2, and 1,000mg/cm^2. These are by convention referred to as "shallow," "eye," and "deep." Table 5.28 lists the deep absorbed dose equivalent in mrem because this is most representative of the dose to the whole body, including the dose to blood forming organs.

An assessment of TLD data quality is based on the presumption that exposures measured at an individual fixed location will remain substantially constant over an extended period of time. A number of factors will combine to affect the certainty of measurements. The total uncertainty of the reported exposures is a combination of random and systematic components

Table 5.27 Offsite Station TLD Results - 1991

Station	Number	Start Date	End Date	# Days	Number of Data Points	Equiv. Exposure Rate (mR/day)[a] Min.	Max.	Ave.	Annual Equiv. Exp. (mR)[b]
Arizona									
Colorado City	008STA230	10/30/90	11/12/91	378	4	0.17	0.19	0.18	65
Jacob's Lake	008STA452	10/30/90	11/12/91	378	4	0.25	0.28	0.26	96
Page	008STA708	10/31/90	11/12/91	378	4	0.13	0.16	0.15	55
California									
Baker	005STA035	11/01/90	11/19/91	378	4	0.23	0.30	0.26	95
Barstow	005STA045	11/01/90	11/19/91	378	4	0.28	0.37	0.32	119
Bishop	005STA095	11/03/90	11/20/91	378	4	0.26	0.36	0.31	111
Death Valley Jct.	005STA290	01/09/91	07/03/91	378	2	0.12	0.21	0.16	60
Furnace Creek	005STA340	01/09/91	07/02/91	378	2	0.07	0.18	0.13	47
Independence	005STA445	11/02/90	11/20/91	378	4	0.23	0.32	0.28	101
Lone Pine	005STA545	11/02/90	11/20/91	378	4	0.23	0.33	0.28	103
Mammoth Geothermal	005STA576	11/03/90	11/20/91	378	4	0.26	0.38	0.32	117
Mammoth Lakes	005STA575	11/03/90	11/20/91	378	4	0.19	0.38	0.30	109
Olancha,	005STA700	11/02/90	11/20/91	378	4	0.22	0.31	0.26	94
Ridgecrest	005STA765	11/02/90	11/20/91	378	4	0.23	0.33	0.27	98
Shoshone	005STA855	11/01/90	11/19/91	378	4	0.20	0.28	0.22	81
Valley Crest	005STA920	01/09/91	04/02/91	83	2	0.06	0.13	0.10	35
Nevada									
Alamo	002STA015	10/30/90	11/12/91	378	3	0.21	0.28	0.23	86
Amargosa Center	007STA825	01/14/91	07/03/91	378	2	0.15	0.30	0.22	82
Amargosa Valley	007STA490	01/14/91	07/01/91	378	2	0.16	0.26	0.21	75
American Borate	007STA910	01/14/91	07/02/91	378	2	0.16	0.31	0.24	87
Atlanta Mine	002STA023	12/04/90	08/28/91	378	2	0.27	0.28	0.27	99
Austin	006STA025	11/07/90	11/18/91	378	4	0.30	0.43	0.36	132
Battle Mountain	005STA055	11/28/90	12/10/91	378	4	0.15	0.28	0.22	80
Beatty	007STA065	01/09/91	07/01/91	378	2	0.17	0.29	0.23	83
Blue Eagle Ranch	003STA106	01/08/91	10/09/91	378	3	0.02	0.30	0.16	60
Blue Jay	004STA115	01/08/91	10/09/91	378	3	0.19	0.45	0.33	120
Cactus Springs	007STA140	11/01/90	11/18/91	378	4	0.14	0.21	0.17	61
Caliente	002STA155	10/29/90	11/12/91	378	3	0.19	0.26	0.22	82
Carp	002STA160	10/29/90	11/15/91	378	3	0.14	0.23	0.18	65
Cherry Creek	009STA210	12/05/90	08/28/91	378	2	0.32	0.34	0.33	120
Clark Station	004STA215	01/08/91	10/09/91	378	3	0.15	0.38	0.28	102
Coaldale	006STA220	11/06/90	11/13/91	378	4	0.19	0.31	0.27	98
Complex 1	003STA240	10/31/90	11/15/91	378	3	0.22	0.29	0.25	93
Corn Creek	001STA295	11/01/90	11/18/91	378	4	0.11	0.19	0.14	50
Cortez/Hwy 278	009STA298	03/12/91	12/10/91	378	3	0.27	0.49	0.41	149
Coyote Summit	004STA230	10/30/90	11/15/91	378	3	0.24	0.37	0.31	113
Crescent Valley	009STA233	11/28/90	12/10/91	378	4	0.14	0.35	0.22	81
Currant	003STA245	01/08/91	10/09/91	378	3	0.14	0.33	0.26	95
Currie	005STA275	12/05/90	08/28/91	378	2	0.33	0.34	0.34	122
Diablo Mtc. Sta.	004STA300	01/03/91	10/08/91	378	3	0.21	0.40	0.33	120
Duckwater	003STA305	01/08/91	10/09/91	378	3	0.13	0.29	0.23	84
Elgin	002STA315	10/29/90	11/15/91	378	3	0.27	0.34	0.29	107
Elko	005STA320	11/27/90	12/10/91	378	4	0.14	0.35	0.21	75

Table 5.27 (Offsite Station TLD Results - 1991, cont.)

Station	Number	Start Date	End Date	# Days	Number of Data Points	Equiv. Exposure Rate (mR/day)[a] Min.	Max.	Ave.	Annual Equiv. Exp. (mR)[b]
Nevada, cont.									
Ely	003STA326	12/05/90	08/27/91	378	2	0.23	0.25	0.24	86
Eureka	006STA333	01/15/91	10/09/91	378	2	0.22	0.31	0.27	97
Fallon	009STA335	11/29/90	12/12/91	378	4	0.13	0.31	0.19	70
Flying Diamond	003STA338	10/31/90	11/15/91	378	3*	0.14	0.22	0.17	64
Gabbs	006STA350	11/06/90	11/13/91	378	4	0.11	0.22	0.18	65
Geyser Ranch	003STA370	12/04/90	08/27/91	378	3	0.11	0.30	0.22	82
Goldfield	006STA380	11/13/90	11/13/91	378	4	0.18	0.31	0.25	91
Groom Lake	004STA400	11/14/90	10/09/91	378	2	0.06	0.28	0.17	61
Hancock Summit	004STA420	11/01/90	11/15/91	378	3	0.33	0.45	0.37	136
Hiko	002STA430	10/30/90	11/16/91	378	3	0.14	0.19	0.17	61
Hot Creek Ranch	004STA440	01/08/91	10/09/91	378	3	0.13	0.25	0.21	75
Indian Springs	007STA450	11/01/90	11/18/91	378	4	0.14	0.25	0.19	70
Ione	011STA452	11/06/90	11/13/91	378	3	0.24	0.31	0.28	104
Kirkeby Ranch	003STA390	12/04/90	08/27/91	378	2	0.18	0.23	0.21	75
Koyne's Ranch	004STA460	11/01/90	11/15/91	378	3	0.18	0.31	0.24	89
Las Vegas Apts.	001STA472	01/02/91	07/02/91	378	2	0.15	0.17	0.16	58
Las Vegas UNLV	001STA485	01/02/91	07/02/91	378	2	0.08	0.13	0.10	37
Las Vegas USDI	001STA480	01/02/91	07/02/91	378	2	0.12	0.19	0.15	55
Lida	006STA500	11/13/90	11/13/91	378	4	0.18	0.31	0.26	95
Lovelock	009STA548	11/28/90	12/11/91	378	4	0.15	0.27	0.19	68
Lund	003STA555	12/06/90	08/29/91	378	2	0.21	0.26	0.23	85
Manhattan	006STA585	11/07/90	11/14/91	378	4	0.25	0.45	0.34	123
Medlin's Ranch	004STA943	11/01/90	11/15/91	378	3	0.23	0.35	0.28	104
Mesquite	001STA615	10/29/90	11/15/91	378	4	0.12	0.16	0.14	51
Mina	006STA620	11/06/90	11/13/91	378	4	0.16	0.29	0.24	86
Moapa	002STA757	10/29/90	11/12/91	378	4	0.17	0.21	0.20	72
Mtn Meadows Ranch	004STA185	01/03/91	10/09/91	378	3	0.13	0.19	0.16	58
Nash Ranch	003STA655	10/30/90	11/16/91	378	3	0.16	0.24	0.19	71
Nyala	004STA690	01/03/91	10/08/91	378	3	0.08	0.25	0.18	66
Overton	001STA705	10/29/90	11/20/91	378	4	0.13	0.15	0.15	54
Pahrump	007STA720	11/01/90	11/19/91	378	4	0.11	0.18	0.14	49
Penoyer Farms	004STA670	10/31/90	11/15/91	378	3	0.24	0.36	0.28	104
Pine Creek Ranch	004STA730	10/31/90	11/15/91	378	3	0.27	0.35	0.30	111
Pioche	002STA740	10/29/90	11/12/91	378	3	0.17	0.19	0.18	66
Queen City Summit	004STA750	01/03/91	10/08/91	378	3	0.24	0.41	0.33	121
Rachel	004STA773	10/31/90	11/15/91	378	3	0.24	0.29	0.26	95
Reed Ranch	004STA760	01/03/91	10/08/91	378	2	0.34	0.35	0.35	127
Reno	009STA757	11/29/90	12/11/91	378	4	0.14	0.33	0.20	71
Round Mountain	006STA775	11/07/90	11/14/91	378	4	0.21	0.35	0.30	108
Ruby Valley	009STA788	11/27/90	12/10/91	378	4	0.24	0.47	0.31	112
So. Desert Corr.	007STA860	11/01/90	11/18/91	378	4	0.12	0.20	0.14	53
Shurz	009STA805	11/29/90	12/12/91	378	4	0.22	0.47	0.29	107
Silver Peak	005STA857	11/13/90	08/22/91	378	4	0.18	0.20	0.19	70
Springdale	007STA885	01/10/91	04/03/91	83	2	0.17	0.31	0.24	88
Steward Ranch	003STA912	12/04/90	03/04/91	90	2	0.29	0.33	0.31	113
Stone Cabin Ranch	004STA915	01/03/91	04/02/91	89	3	0.14	0.33	0.26	94
Sunnyside	003STA930	12/06/90	03/06/91	90	2	0.13	0.16	0.14	53

Table 5.27 (Offsite Station TLD Results - 1991, cont.)

Station	Number	Start Date	End Date	# Days	Number of Data Points	Equiv. Exposure Rate (mR/day)[a] Min.	Max.	Ave.	Annual Equiv. Exp. (mR)[b]
Nevada, cont.									
Tempiute	004STA940	11/01/90	02/05/91	96	3	0.26	0.31	0.28	104
Tonopah Test Range	006STA947	01/02/91	04/10/91	98	3	0.24	0.50	0.36	130
Tonopah	006STA945	11/07/90	02/07/91	92	4	0.29	0.32	0.31	113
Twin Springs Ranch	004STA955	01/03/91	04/01/91	88	3	0.09	0.40	0.26	95
Uhalde's Ranch	004STA010	10/31/90	02/05/91	97	3	0.26	0.32	0.29	106
Warm Springs #1	004STA975	01/03/91	04/02/91	89	3	0.20	0.39	0.32	116
Warm Springs #2	004STA977	01/03/91	04/02/91	89	3	0.94	1.15	1.04	378
Wells	005STA985	11/27/90	03/12/91	105	4	0.17	0.36	0.23	84
Winnemucca	009STA998	11/28/90	03/13/91	105	4	0.12	0.37	0.21	78
Young's Ranch	006STA980	08/22/90	02/06/91	168	4	0.07	0.26	0.21	75
Utah									
Boulder	010STA116	12/05/90	12/11/91	378	4	0.18	0.29	0.23	85
Bryce Canyon	010STA118	12/05/90	12/11/91	378	4	0.18	0.24	0.21	77
Cedar City	001STA200	11/28/90	12/09/91	378	4	0.16	0.23	0.19	71
Delta	011STA295	01/30/91	01/09/92	378	3	0.15	0.34	0.22	81
Duchesne	011STA303	01/29/91	01/07/92	378	3	0.12	0.27	0.18	66
Enterprise	001STA325	11/27/90	12/09/91	378	4	0.26	0.39	0.32	116
Ferron	008STA337	01/29/91	01/07/92	378	3	0.12	0.30	0.18	67
Garrison	003STA360	12/05/90	08/28/91	378	2	0.22	0.22	0.22	80
Grantsville	011STA393	01/30/91	01/09/92	378	3	0.15	0.29	0.20	73
Green River	008STA395	08/07/90	11/12/91	378	4	0.04	0.21	0.15	54
Gunnison	008STA405	12/06/90	12/10/91	378	4	0.13	0.16	0.15	54
Ibapah	009STA443	12/05/90	08/28/91	378	2	0.24	0.34	0.29	106
Kanab	008STA453	10/30/90	11/12/91	378	4	0.11	0.17	0.14	52
Loa	010STA520	12/05/90	12/11/91	378	4	0.28	0.39	0.33	122
Logan	011STA530	01/10/91	07/05/91	378	2	0.15	0.24	0.20	72
Lund	010STA560	11/28/90	12/09/91	378	4	0.25	0.34	0.28	104
Milford	001STA620	12/04/90	12/10/91	378	4	0.28	0.37	0.32	118
Monticello	008STA650	10/31/90	11/13/91	378	4	0.22	0.23	0.23	83
Nephi	011STA660	12/06/90	12/10/91	378	4	0.13	0.18	0.16	58
Parowan	010STA725	12/04/90	12/12/91	378	4	0.18	0.20	0.19	70
Price	011STA743	01/29/91	01/07/92	378	3	0.15	0.30	0.20	74
Provo	011STA745	01/29/91	01/08/92	378	3	0.13	0.23	0.18	65
Salt Lake City	001STA800	01/30/91	01/08/92	378	3	0.12	0.21	0.17	61
St. George	001STA795	11/28/90	03/01/91	93	4	0.12	0.14	0.12	45
Trout Creek	009STA948	12/05/90	03/05/91	90	2	0.20	0.23	0.21	78
Vernal	011STA973	01/29/91	04/09/91	70	3	0.13	0.29	0.19	71
Vernon	011STA974	01/30/91	04/10/91	70	3	0.17	0.33	0.22	82
Wendover	005STA990	11/27/90	03/12/91	105	4	0.10	0.30	0.17	64
Willow Spr. Lodge	011STA997	01/30/91	04/10/91	70	3	0.13	0.26	0.18	66

(a) Daily exposure rates are obtained by dividing the total exposure from each TLD by the number of days in the measurement period.

(b) Annual exposures are calculated by multiplying average daily exposure rate by 365.25.

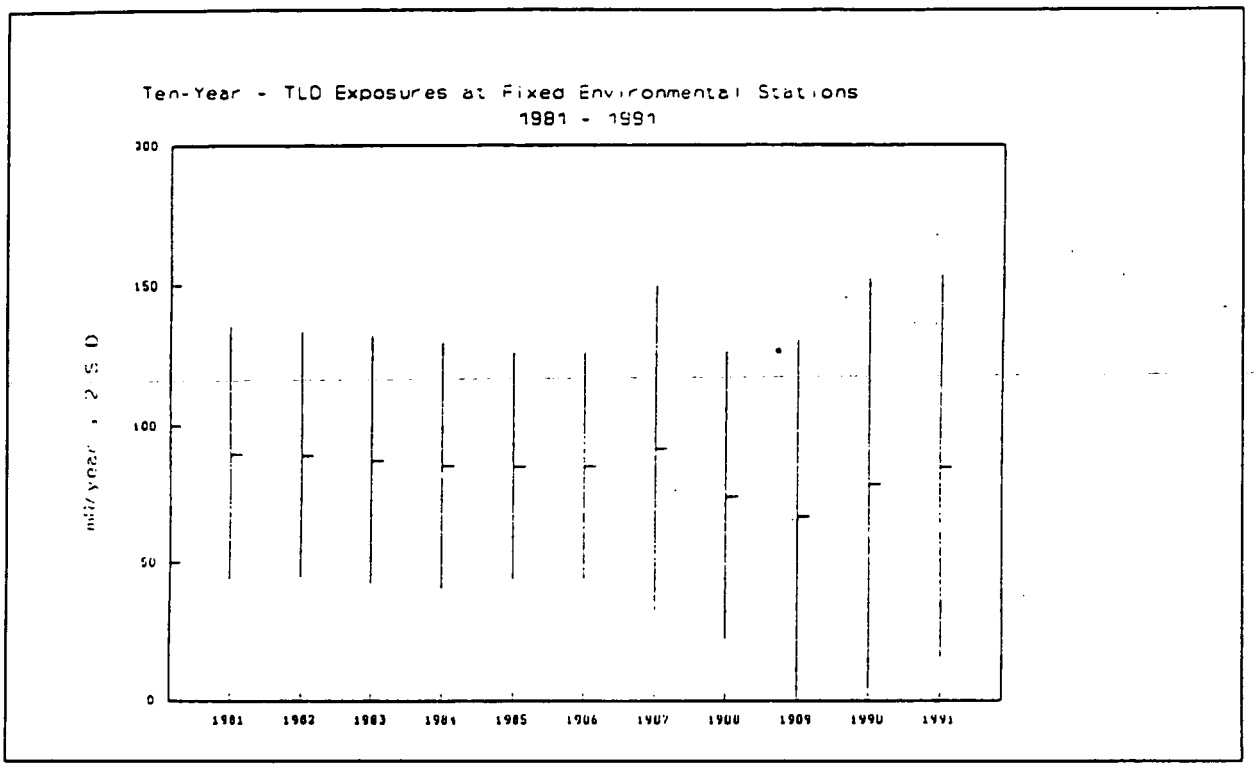

Figure 5.14 Ten Years of TLD Exposures at All Fixed Environmental Stations

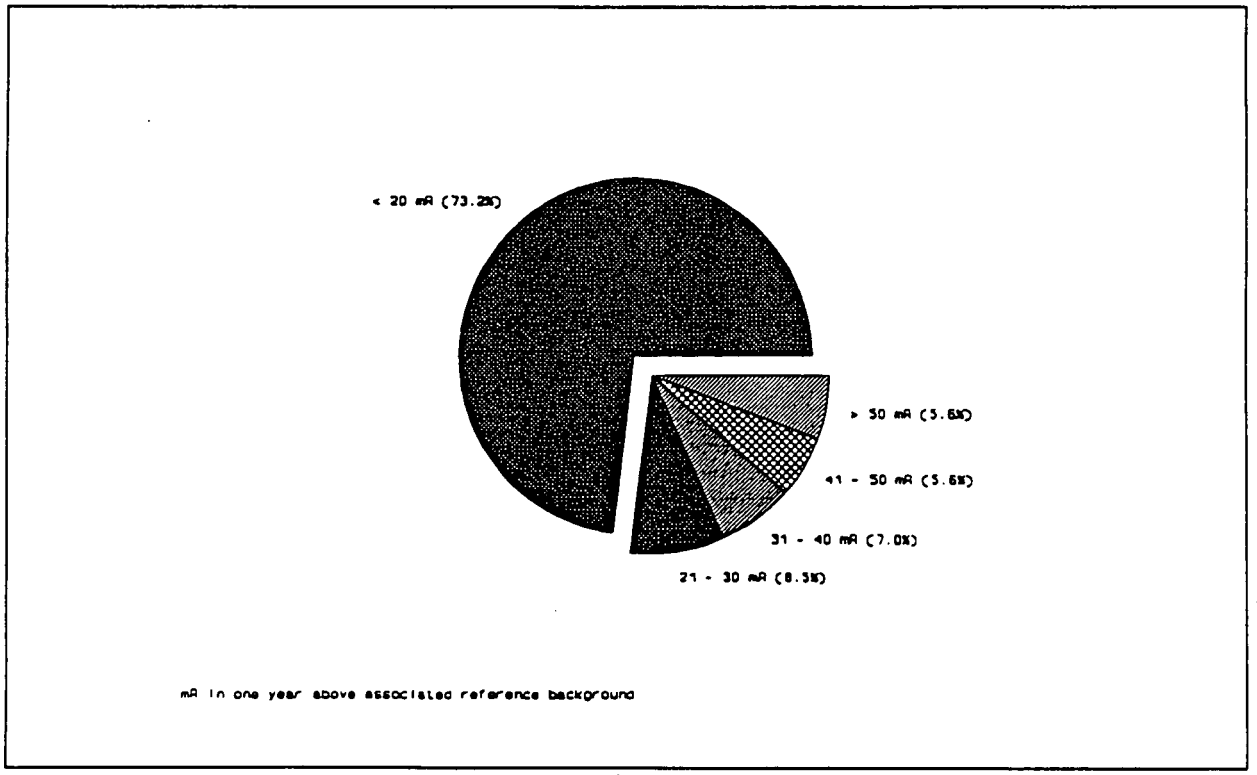

Figure 5.15 Personnel Exposures Compared to Associated Reference Background

Table 5.28 Offsite Personnel TLD Results, 1991

Person I.D./ Location	Background Station	Start Date	End Date	# Days	Number of Data Points	Equiv.Deep Dose Rate (mrem/day)[a] Min.	Max.	Ave.	Annual Equiv. Dose (mrem)[b]
California									
304/Death Valley Jct.	005STA290	01/09/91	07/03/91	175	6	0.18	0.55	0.36	133
359/Death Valley Jct.	005STA290	01/10/91	07/11/91	182	6	0.06	0.43	0.21	76
60/Shoshone	005STA855	01/08/91	07/08/91	181	6	0.14	0.52	0.29	105
404/Shoshone	005STA855	01/08/91	07/08/91	181	6	0.10	0.68	0.34	123
Nevada									
22/Alamo	002STA015	01/03/91	08/05/91	214	7	0.03	0.18	0.10	38
427/Alamo	002STA015	01/03/91	08/06/91	215	7	0.05	0.39	0.18	66
380/Amargosa Center	007STA825	01/03/91	07/02/91	180	6	0.18	0.57	0.30	114
426/Amargosa Valley	012YCA023	01/03/91	07/02/91	180	6	0.24	0.56	0.37	135
329/Austin	006STA025	01/16/91	07/09/91	174	6	0.19	0.57	0.30	111
21/Beatty	007STA065	01/10/91	07/02/91	173	6	0.09	0.44	0.29	105
38/Beatty	007STA065	01/09/91	07/01/91	173	6	0.21	0.41	0.28	102
358/Beatty	007STA065	01/11/91	07/02/91	172	6	0.15	0.42	0.30	111
429/Beatty	007STA065	02/12/91	07/02/91	140	5	0.03	0.35	0.21	78
9/Blue Eagle Ranch	003STA106	01/08/91	07/16/91	189	6	0.11	0.31	0.22	79
2/Caliente	002STA155	01/02/91	08/06/91	216	7	0.21	0.36	0.32	117
336/Caliente	002STA155	01/02/91	08/01/91	211	7	0.05	0.27	0.16	58
10/Complex 1	003STA240	01/03/91	08/06/91	215	7	0.11	0.50	0.30	110
11/Complex 1	003STA240	01/03/91	08/06/91	215	7	0.07	0.36	0.19	69
56/Corn Creek	001STA295	01/02/91	08/31/91	241	8	0.04	0.26	0.15	59
14/Coyote Summit	004STA230	01/04/91	08/13/91	221	7	0.12	0.36	0.22	81
15/Coyote Summit	004STA230	01/04/91	08/13/91	221	7	0.04	0.34	0.18	65
47/Ely	003STA326	01/02/91	07/12/91	191	6	0.06	0.30	0.18	67
444/Ely	003STA326	07/10/91	08/06/91	27	1	0.18	0.18	0.18	66
302/Gabbs	006STA350	01/15/91	07/10/91	176	6	0.04	0.39	0.22	79
7/Goldfield	006STA380	01/17/91	07/11/91	175	6	0.07	0.76	0.35	127
19/Goldfield	006STA380	01/17/91	07/11/91	175	6	0.04	0.39	0.21	76
40/Goldfield	006STA380	01/17/91	07/11/91	175	6	0.10	0.28	0.18	66
424/Terrell's Ranch	012YCA810	01/10/91	07/02/91	173	5	0.05	0.52	0.29	105
232/Hiko	002STA430	01/04/91	08/06/91	214	7	0.03	0.19	0.13	46
3/Hot Creek Ranch	004STA440	01/09/91	07/16/91	188	6	0.12	0.29	0.20	73
6/Indian Springs	007STA450	01/07/91	07/08/91	182	6	0.04	0.52	0.20	72
37/Indian Springs	007STA450	01/07/91	07/08/91	182	6	0.04	0.44	0.18	64
405/Indian Springs	007STA450	01/07/91	07/08/91	182	6	0.06	0.24	0.15	54
381/Ione	011STA452	01/15/91	07/10/91	176	6	0.10	0.50	0.28	102
300/Koyne's Ranch	004STA460	01/03/91	08/06/91	215	7	0.05	0.46	0.17	64
49/Las Vegas UNLV	001STA485	01/31/90	04/02/91	426	3	0.03	0.24	0.11	39
25/Las Vegas USDI	001STA480	01/02/91	08/31/91	241	8	0.02	0.19	0.09	34
297/Las Vegas USDI	001STA480	01/02/91	08/31/91	241	8	0.04	0.20	0.11	39
326/Las Vegas USDI	001STA480	01/02/91	05/02/91	120	4	0.11	0.19	0.14	50
376/Las Vegas USDI	001STA480	01/02/91	07/31/91	210	7	0.03	0.44	0.14	50
377/Las Vegas USDI	001STA480	01/02/91	08/31/91	241	8	0.03	0.22	0.10	36
398/Las Vegas USDI	001STA480	01/02/91	08/31/91	241	8	0.04	0.40	0.26	94
399/Las Vegas USDI	001STA480	01/02/91	08/31/91	241	8	0.00	0.35	0.20	72
402/Las Vegas USDI	001STA480	01/02/91	08/31/91	241	8	0.04	0.32	0.15	56
403/Las Vegas USDI	001STA480	01/02/91	08/31/91	241	8	0.04	0.27	0.15	56

Table 5.28 (Offsite Personnel TLD Results, 1991, cont.)

Person I.D./ Location	Background Station	Start Date	End Date	# Days	Number of Data Points	Equiv.Deep Dose Rate (mrem/day)[a] Min.	Max.	Ave.	Annual Equiv. Dose (mrem)[b]
423/Las Vegas USDI	001STA480	08/01/91	08/31/91	30	0	DOSIMETER NOT RETURNED			
428/Las Vegas USDI	001STA480	01/03/91	08/31/91	240	8	0.02	0.44	0.24	87
379/Manhattan	006STA585	01/16/91	07/09/91	174	6	0.09	0.46	0.32	116
307/Mina	006STA620	01/15/91	07/10/91	176	6	0.02	0.30	0.18	67
18/Nyala	004STA690	01/03/91	07/16/91	194	6	0.07	0.33	0.18	64
348/Overton	001STA705	01/02/91	08/01/91	211	7	0.18	0.29	0.23	83
372/Pahrump	007STA720	01/03/91	07/01/91	179	6	0.05	0.22	0.15	55
410/Pahrump	007STA720	01/08/91	07/08/91	181	6	0.03	0.58	0.26	94
411/Pahrump	007STA720	01/08/91	07/08/91	181	6	0.03	0.44	0.26	96
248/Penoyer Farms	004STA670	01/03/91	08/06/91	215	7	0.16	0.38	0.22	82
293/Pioche	002STA740	01/02/91	08/05/91	215	7	0.03	0.39	0.15	56
264/Rachel	004STA773	01/04/91	08/06/91	214	7	0.13	0.31	0.25	92
334/Rachel	004STA773	01/03/91	08/06/91	215	7	0.16	0.26	0.20	75
443/Rachel	004STA773	07/10/91	08/06/91	27/	1	0.09	0.09	0.09	32
299/Round Mountain	006STA775	01/16/91	07/09/91	174	6	0.09	0.57	0.29	107
341/Silver Peak	005STA857	01/17/91	07/10/91	174	6	0.05	0.57	0.31	112
29/Stone Cabin Ranch	004STA915	01/03/91	07/16/91	194	6	0.24	0.68	0.46	167
42/Tonopah	006STA945	01/17/91	07/11/91	175	6	0.09	0.54	0.30	110
339/Tonopah	006STA945	01/17/91	07/10/91	174	6	0.16	0.50	0.31	113
370/Twin Springs Ranch	004STA955	01/03/91	07/16/91	194	6	0.21	0.39	0.32	118
Utah									
44/Cedar City	001STA200	01/02/91	08/01/91	211	7	0.09	0.39	0.20	71
344/Delta	011STA295	01/02/91	08/06/91	216	7	0.08	0.19	0.15	54
345/Delta	011STA295	01/02/91	08/06/91	216	7	0.09	0.50	0.25	90
346/Milford	001STA620	01/02/91	08/05/91	215	7	0.15	0.34	0.24	89
347/Milford	001STA620	01/02/91	08/05/91	215	7	0.08	0.61	0.39	143
52/Salt Lake City	001STA800	01/02/91	08/06/91	216	7	0.06	0.26	0.17	63
45/St. George	001STA795	01/02/91	08/02/91	212	7	0.03	0.14	0.08	31

USDI - United States Department of Interior
UNLV - University of Nevada, Las Vegas

(a) Daily dose rates are obtained by dividing the total dose from each TLD by the number of days in the measurement period.
(b) Annual doses are calculated by multiplying average daily dose rate by 365.25.

of uncertainty. The random component is primarily the statistical uncertainty in the reading of the TLD elements themselves. Based on repeated known exposures, this random uncertainty for the calcium sulfate elements used to determine exposure to fixed environmental stations is estimated to be approximately ± 3 to 5%. There are also several systematic components of exposure uncertainty, including energy-directional response, fading, calibration, and exposures received while in storage. These uncertainties are propagated according to established statistical methods for propagation of uncertainty. A study conducted by the Nuclear Regulatory Commission indicated an average total net field exposure uncertainty for fixed environmental station TLDs deployed for a period of 90 days of 21.1%, expressed in terms of % RSD.

A review of fixed environmental station TLD results obtained by the EPA network in 1991 showed an average % RSD for all stations of 21.6 %, virtually identical to the results reported by NRC. Also, the NRC reported an average net field exposure of 22.8 mR in 90 days. Results observed in the EPA monitoring network averaged 21.6 mR when adjusted to the same length monitoring period. Net field exposure uncertainty for exposures at the occupational and accident range of 30 mR to 500 R would be significantly lower due to the much higher exposure levels when compared to natural background or transit exposure levels.

From these independent studies of fixed environmental monitoring performance and the results of our U.S. Department of Energy Laboratory Accreditation Program (DOELAP) performance testing for personnel monitoring, it is concluded that the quality of data generated from the EPA TLD monitoring network is in accordance with generally accepted standards of good dosimetry practice.

5.2.2.5 PRESSURIZED ION CHAMBER NETWORK

The locations of the twenty-nine Pressurized Ion Chambers (PICs) stationed around the Nevada Test Site are shown in Figure 4.12 (Chapter 4). The PIC data presented in this section are based on weekly averages of gamma exposure rates from each station. Weekly averages were compiled from 4-hour averages transmitted by the telemetry system when available and from the 5-minute averages from the magnetic tapes or cards when the telemetry system data were unavailable.

Data transmitted via the telemetry system were compared to the magnetic tape data on a weekly basis to check that both systems were reporting the same numbers. Whenever weekly averages from the two sets of numbers were not in agreement, the cause of the discrepancy was investigated and corrected.

Weekly averages were compiled for every station, for every week during 1991 with the following exceptions: Austin, weeks-ending June 6, June 26, and July 2; Furnace Creek, weeks-ending June 26 and July 2; St. George, weeks-ending September 11 and December 4; Salt Lake City, week-ending December 4; Shoshone, week-ending November 13; Terrel's Ranch, weeks-ending January 16 and December 17; Uhalde's Ranch, week-ending October 1. Data were unavailable during these weeks due to equipment failure.

Figure 5.16 shows the distribution of the weekly averages from each station arranged by ascending medians. The bottom and top edges of the box on the graph represent the 25th and 75th percentiles of the distribution of the weekly averages (i.e., 50% of the data falls within this region). The horizontal line drawn inside the box represents the 50th percentile or the median value. The vertical lines extend from the box to the minimum and maximum values. The data from Austin, Nevada show the greatest amount of variability. This is probably due to seasonal differences in gamma exposure rates which have historically been seen at this station.

Table 5.29 contains the number of weekly averages available from each station and the mean, standard deviation, minimum, maximum, and median of the weekly averages. The mean ranged from 5.9 μR/hr at Las Vegas, Nevada to 17.6 μR/hr at Stone Cabin Ranch, Nevada. For each station, this table also shows the total mR/yr (calculated based on the weekly averages).

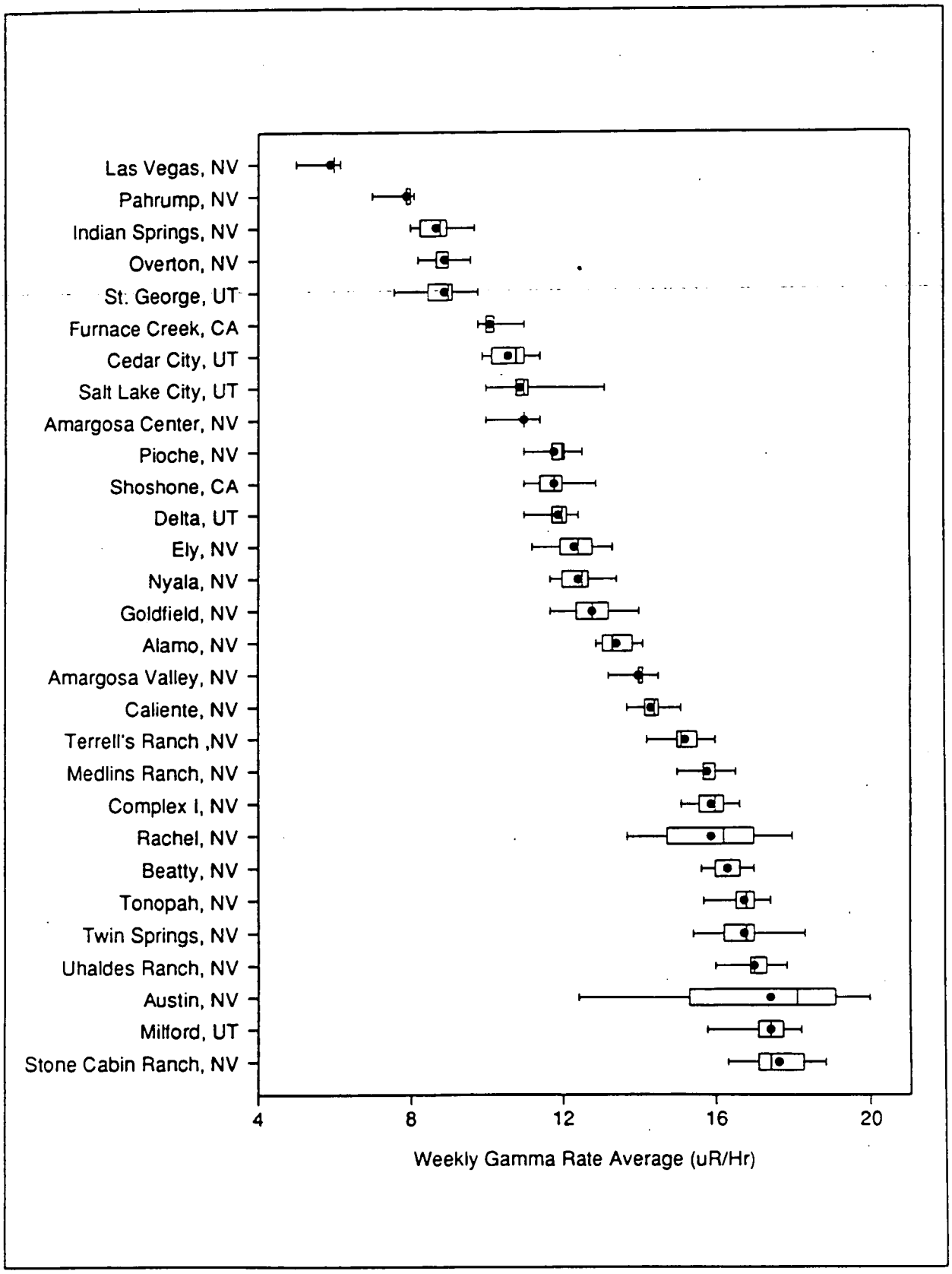

Figure 5.16 Distribution of Weekly PIC Averages From Sampling Stations - 1991

Table 5.29 Summary of Weekly Gamma Exposure Rates as Measured by Pressurized Ion Chambers, 1991

Station	Number of Weekly Averages	Gamma Exposure Rate (μR/hr) Mean ± 1s	Minimum	Maximum	Median	mR/yr
Alamo, NV	52	13.4 ± 0.4	12.9	14.1	13.3	118
Amargosa Center, NV	52	11.0 ± 0.2	10.0	11.4	11.0	96
Amargosa Valley, NV	52	14.0 ± 0.2	13.2	14.5	14.0	122
Austin, NV	49	17.4 ± 2.2	12.4	20.0	18.1	152
Beatty, NV	52	16.3 ± 0.4	15.6	17.0	16.0	142
Caliente, NV	52	14.3 ± 0.3	13.7	15.1	14.4	126
Cedar City, UT	52	10.6 ± 0.4	9.9	11.4	10.8	93
Complex I, NV	52	15.9 ± 0.4	15.1	16.6	16.0	139
Delta, UT	52	11.9 ± 0.3	11.0	12.4	12.0	104
Ely, NV	52	12.3 ± 0.6	11.2	13.3	12.4	108
Furnace Creek, CA	50	10.1 ± 0.3	9.8	11.0	10.0	89
Goldfield, NV	52	12.8 ± 0.5	11.7	14.0	12.8	112
Indian Springs, NV	52	8.7 ± 0.4	8.0	9.7	8.8	76
Las Vegas, NV	52	5.9 ± 0.2	5.0	6.2	6.0	52
Medlins Ranch, NV	52	15.8 ± 0.3	15.0	16.5	16.0	139
Milford, UT	52	17.4 ± 0.5	15.8	18.2	17.4	152
Nyala, NV	52	12.4 ± 0.4	11.7	13.4	12.5	109
Overton, NV	52	8.9 ± 0.3	8.2	9.6	9.0	78
Pahrump, NV	52	7.9 ± 0.3	7.0	8.1	8.0	69
Pioche, NV	52	11.8 ± 0.4	11.0	12.5	12.0	104
Rachel, NV	52	15.9 ± 1.2	13.7	18.0	16.2	139
Salt Lake City, UT	51	10.9 ± 0.5	10.0	13.1	11.0	96
Shoshone, CA	51	11.8 ± 0.4	11.0	12.9	11.8	103
St. George, UT	50	8.9 ± 0.4	7.6	9.8	9.0	78
Stone Cabin Rnch, NV	52	17.6 ± 0.7	16.3	18.8	17.4	154
Terrels Ranch ,NV	50	15.2 ± 0.4	14.2	16.0	15.1	133
Tonopah, NV	52	16.7 ± 0.4	15.7	17.4	16.8	146
Twin Springs, NV	52	16.7 ± 0.6	15.4	18.3	16.8	146
Uhaldes Ranch, NV	51	17.0 ± 0.4	16.0	17.8	17.0	149

Note: Multiply μR/hr by 2.6×10^{-10} to obtain $C \cdot kg^{-1} \cdot h^{-1}$.

Background levels of environmental gamma exposure rates (from the combined effects of terrestrial and cosmic sources) vary between 42 and 247 mR/yr (BEIR 1980). The annual exposure levels observed at each station are well within the U.S. background levels. The PIC data from 1991 are consistent with data from previous years. The greatest difference in averages between 1990 and 1991 was seen at Goldfield, Nevada. This was probably because the sensor unit, which was exchanged in February of 1991, was slightly underestimating the gamma exposure rate. The 1992 exposure rates at Goldfield are expected to resemble the levels seen in 1990.

5.2.2.6 COMPARISON OF TLD RESULTS TO PIC MEASUREMENTS

When calculated TLD exposures are compared with results obtained from collocated PICs (see Figure 5.17), a uniform under-response of TLDs was noted. This difference, which has been observed in previous years, is attributed primarily to the differing energy response of the two systems. The PICs have a greater sensitivity to lower energy gamma radiation than the

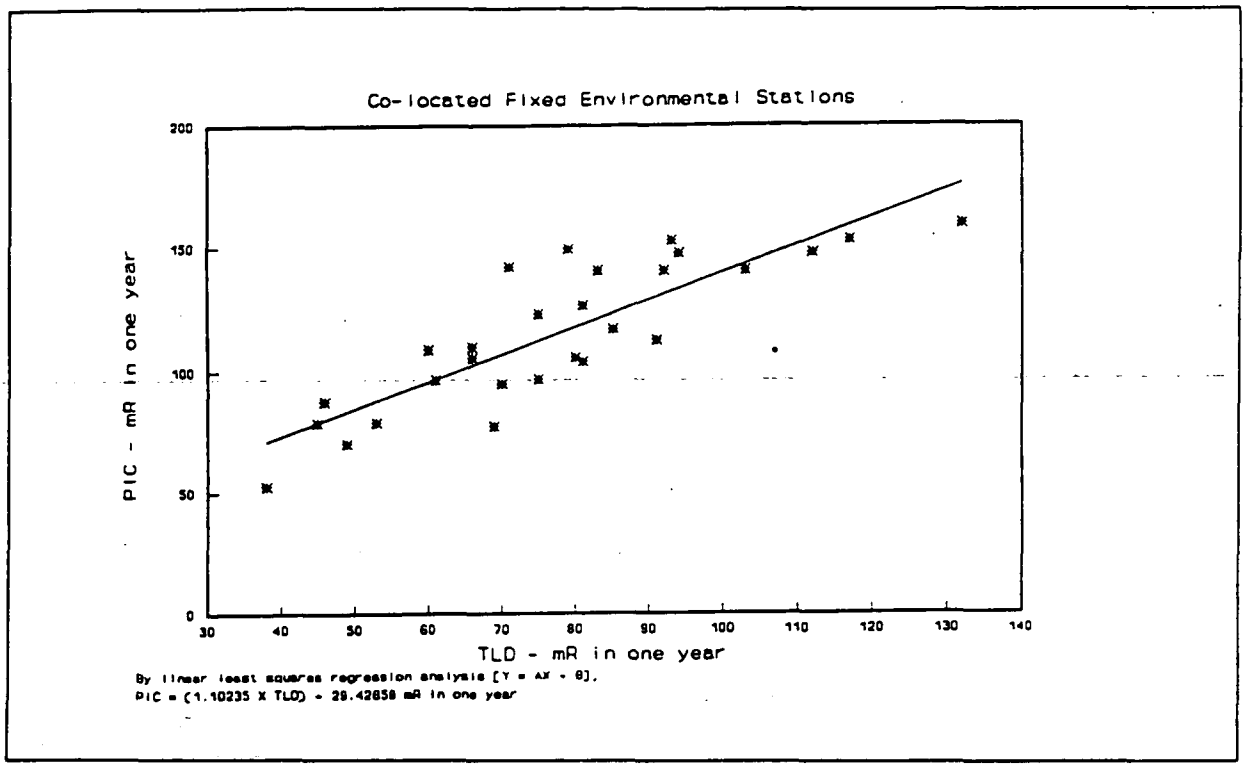

Figure 5.17 Comparison of TLD Exposures and Colocated PIC Results

TLDs and hence will normally record a higher apparent exposure rate than do the TLDs. This difference is attributed to three primary factors:

- The PIC is an exposure rate measuring device, sampling every five seconds, while the TLD as an integrating dosimeter is analyzed approximately once each quarter. Some reduction in TLD results may be due to a small amount of loss due to normal fading (studies by Panasonic have shown this loss to be minimal over the sampling period used). A six-month fade study was conducted by the EMSL-LV TLD Laboratory. This study confirmed that, over the normal sampling period, fading is negligible.

- PICs are more sensitive to lower energy gamma radiation than are the TLDs. A review of manufacturer's specifications for the PIC and TLD systems shows their responses to be close to linear above approximately 80 and above approximately 150 keV, respectively; and

- The PIC units are calibrated by the manufacturer against ^{60}Co, while the TLDs are calibrated using ^{137}Cs. No adjustment is made to account for the differing energies at which the two systems are calibrated.

Although these known systematic differences occur, both the TLD and PIC networks serve as valuable components of an overall environmental radiation monitoring program, each with unique capabilities.

5.2.2.7 OFFSITE DOSIMETRY NETWORK

During 1991 EPA obtained a total of 2800 gamma spectra from whole-body counting of 350 individuals, of whom 106 were participants in the Offsite Internal Dosimetry Network (see Chapter 4, Figure 4.13 for the location of the participating families). The remaining individuals were radiation workers, including EPA, DOE, and contractor personnel. In general the spectra were representative of normal background and showed only naturally occurring ^{40}K. No transuranic radionuclides were detected in any lung counting data.

Bioassay results for single urine samples collected at random periods of time from participates in the Offsite Dosimetry Network showed only two samples with tritium concentrations greater than the MDC. The MDC average value was 2.7×10^{-7}pCi/mL; the greatest tritium concentration detected in a sample was 3.8×10^{-7}pCi/mL. This highest value is only 0.01 percent of the annual limit of intake for the general public. Both of the values that were slightly above the MDC could be the result of random statistical fluctuation. No additional bioassay sampling was performed. The average value for 98 samples analyzed for tritium in urine was 8.9×10^{-9} pCi/mL. A complete listing of bioassay results is provided in Appendix D.

As reported in previous years, medical examinations of the offsite families revealed a generally healthy population. The blood examinations and thyroid profiles showed no symptoms which could be attributed to past or present NTS testing operations. A family member of one of the CRMS station managers died of cancer in 1991, however the type of cancer is not one normally associated with radiation exposure from effluent releases at NTS. External exposure data as measured by TLDs are presented in Section 5.2.2.4.

5.2.2.8 MILK SURVEILLANCE NETWORK

The Milk Surveillance Network (MSN) has three components: a routine network, a standby network (SMSN), and a dairy animal and population census. Milk is an important part of man's food chain. Because dairy animals consume vegetation that represents a large area of ground cover and because many radionuclides can be transferred to milk, analysis of milk samples may yield information on the deposition of small amounts of radionuclides over a relatively large area. Radioiodine concentrations in milk are responsible for the largest early time exposure to infants and children.

As in the other networks, MSN collection locations are distributed around the NTS but are limited to those places that have family dairy cows or goats or where commercial dairies exist. Collection sites for the MSN are shown in Figure 4.8 (Chapter 4). The SMSN consists of about 120 dairies or processing plants in all states west of the Mississippi River and is activated annually to monitor trends and ensure proper operation in case of an emergency. The network is activated by contacting the FDA Regional Milk Specialists who in turn contact State Dairy Regulators to enlist cooperating milk processors or producers. Collection sites for the SMSN are shown in Figure 4.9 (Chapter 4). The dairy animal and population census is continually updated for those areas within 240 miles north and east of CP-1 and within 125 miles south and west of it. The remainder of the Nevada counties and the western-most Utah counties are surveyed approximately every other year. The next full census is scheduled for the spring of 1992. The locations of processing plants and commercial dairy herds in Idaho and the remainder of Utah can be obtained from the milk and food sections of the respective state governments.

In 1991, six locations in Texas were added to the SMSN. No samples were received from the Lompoc, California SMSN station, nor from two MSN sites in Goldfield, Nevada and one MSN location in Warm Springs, Nevada. Four new MSN sites were added in 1991 (month of first collection shown in parentheses): John Deer Ranch (March) and Bar-B-Q Ranch (July) Ranches in Amargosa Valley, Nevada, Karen Harper (October) in Tonopah, Nevada, and Bradshaw's Ranch (November) in Duckwater, Nevada.

All samples were analyzed for gamma-emitting radionuclides and only naturally occurring ^{40}K was detected. Selected milk samples were also analyzed for ^{3}H, ^{89}Sr, and ^{90}Sr. A summary of the values exceeding the MDC of the analysis is provided in Table 5.30 with corresponding values from the 1990 data set. Also shown are the network averages for both years. These results are fairly consistent with those obtained in previous years and are not indicative of either an increasing or decreasing trend in either network. Complete listings of all analytical results for the MSN and SMSN samples is contained in Appendix D.

Table 5.30 Summary of Radionuclides Detected in Milk Samples

	Milk Surveillance Network				Standby Milk Surveillance Network			
	No. of Stations with results > MDC		Network Average Concentrations (pCi/L)		No. of Stations with results > MDC		Network Average Concentrations (pCi/L)	
	1991	1990	1991	1990	1991	1990	1991	1990
^{3}H	2	0	152	129	1	1	153	159
^{89}Sr	1	0	0.303	0.179	3	0	0.420	-0.161
^{90}Sr	4	4	0.546	0.585	18	17	1.236	1.324

6.0 DOSE ASSESSMENT

William G. Phillips and Stuart C. Black

The extensive offsite environmental surveillance system operated around the NTS by EPA EMSL-LV measured no radiological exposures that could be attributed to recent NTS operations. Calculation of potential Effective Dose Equivalents (EDE) to offsite residents, based on onsite source emission measurements provided by DOE and calculated by EPA's CAP88-PC model, resulted in a maximum calculated dose of 8.6×10^{-3} mrem (8.6×10^{-5} mSv) to a hypothetical resident of Springdale, NV, 72 kilometers (45 miles) west of the NTS CP-I. Monitoring network data indicated a 1991 dose of 142 mrem from normal background radiation occurring in the Beatty area near Springdale. The calculated dose to this individual from world wide distributions of radioactivity as measured from surveillance networks was 6.3×10^{-2} mrem. The calculated population dose (collective effective dose equivalent) to the approximately 21,752 residents living within 80 km (50 mi.) from each of the NTS airborne emission sources was 4.2×10^{-2} person-rem (4.2×10^{-4} person-sievert). Further, if an NTS deer with the measured concentration of $^{239+240}Pu$ in meat were to be collected by a hunter offsite, and the hunter ate all the 45 kg (100 lb) of meat, he/she would have received an EDE of 2.7×10^{-2} mrem. All of these maximum dose estimates are much less than 1% of the most restrictive standard.

6.1 ESTIMATED DOSE FROM NEVADA TEST SITE ACTIVITIES

The estimated Effective Dose Equivalent (EDE) to the offsite population due to NTS activities was based on the total release of radioactivity from the NTS in 1991 as listed in Table 5.1. As no radioactivity of recent NTS origin was detectable offsite by the various monitoring networks, no measurable exposure to the population living around the NTS was expected. To confirm this expectation, a calculation of estimated dose was performed using EPA's CAP88-PC model. The individuals exposed were considered to be all of those living within a radius of 80 km (50 mi.) of each of the sources listed in Table 5.1, a total of 21,752 individuals. The hypothetical individual with the maximum calculated EDE from airborne NTS radioactivity would have been continuously present at Springdale, Nevada, 72 kilometers (45 miles) west of CP-I (Figure 6.1). That maximum EDE to that individual was 8.6×10^{-3} mrem (8.6×10^{-5} mSv). The collective population EDE within 80 km from the airborne emission sources was calculated to be 4.2×10^{-2} person-rem (4.2×10^{-4} person-Sv). The concentrations in air that would cause these calculated doses are too small to be detected by the offsite monitoring network.

During calendar year 1991, there were four pathways of possible radiation exposure to the population of Nevada that were monitored by the offsite monitoring networks. The four pathways were:

- Operational releases of radioactivity from the NTS, including those from drillback and purging activities.

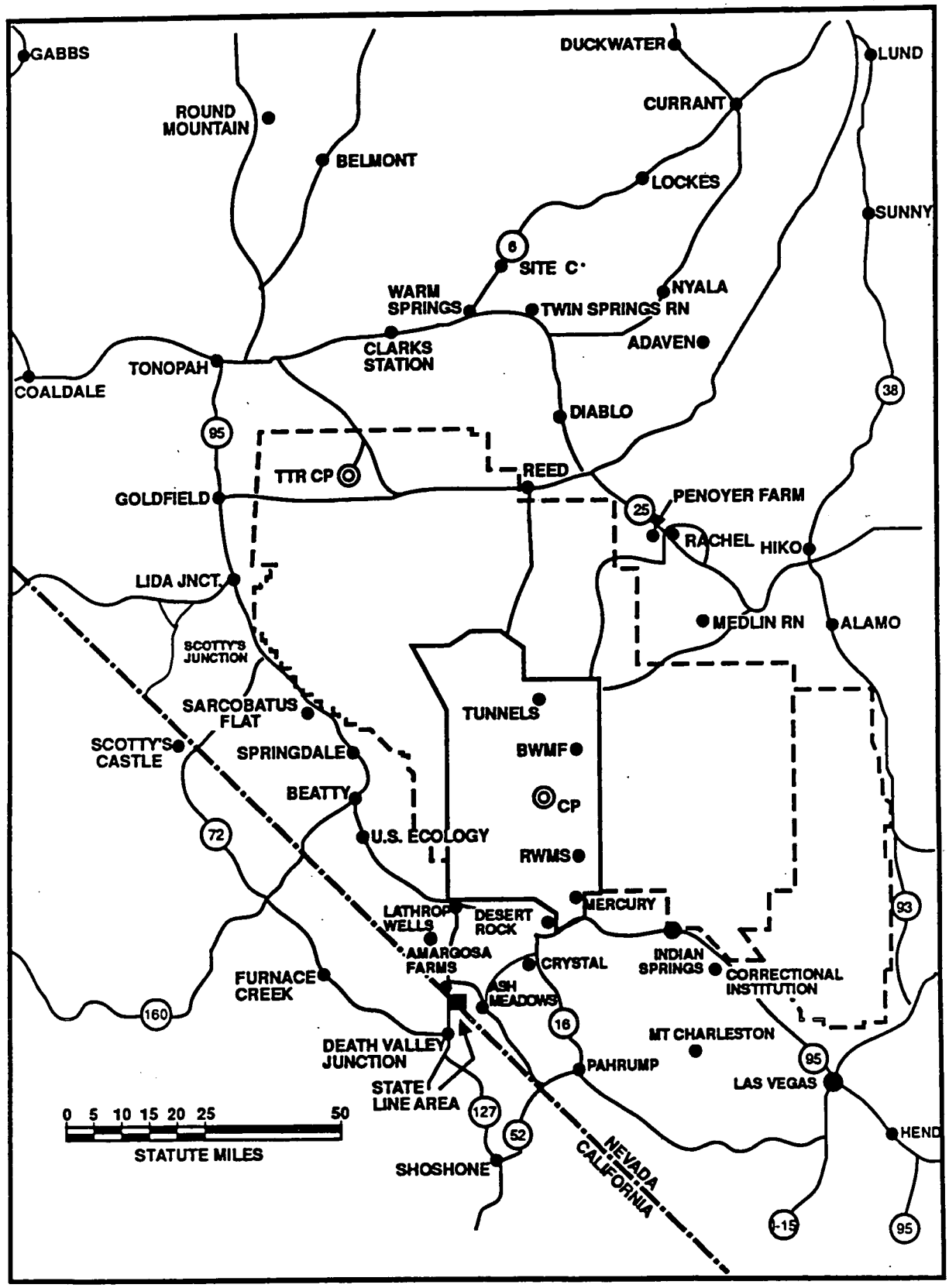

Figure 6.1 Map of the Area Around the NTS

- Radioactivity that was accumulated in migratory game animals during their residence on the NTS.
- Worldwide distributions of radioactivity, such as ^{90}Sr in milk, ^{85}Kr in air, and plutonium in soil.
- Background radiation due to natural sources such as cosmic radiation, natural radioactivity in soil, and ^{7}Be in air.

The estimated dose equivalent exposures from these sources to persons living near the NTS are calculated separately and presented in the subsections below. Table 1.2 (Chapter 1), reproduced below, summarizes the annual effective dose equivalents due to operations at the NTS during 1991 as calculated by with the EPA computer program CAP88-PC using the released radionuclides listed in Table 5.1.

6.2 ESTIMATED DOSE TO HUMANS FROM WORLDWIDE FALLOUT

From the concentrations measured by the surveillance networks during 1991, using appropriately conservative assumptions and dose conversion factors as presented below, potential individual dose equivalents may be estimated.

6.2.1 MEAN ACTIVITY CONCENTRATIONS

- **Air**

  ^{3}H: 0.5 pCi/m^3 of air (1.8 x 10^{-2} Bq/m^3)

  ^{85}Kr: 26.4 pCi/m^3 of air (1 Bq/m^3)

  $^{239+240}Pu$: 1.1 x 10^{-12} pCi/m^3 of air at Las Vegas (4 x 10^{-14} Bq/m^3)

- **Milk**

  ^{90}Sr: 0.6 pCi/L in milk (2.2 x 10^{-2} Bq/L)

  ^{3}H: 152 pCi/L in milk (5.6 Bq/L), Average of 77 MSN samples.

- **Surface Drinking water**

  ^{3}H: 3.4 pCi/L, Average of results from Coffer's, Spicer's, Younghans', and Beatty City wells, all of which are near Springdale, Nevada.

- **Animals**

  $^{238,239,240}Pu$: 4.4 x 10^{-2} pCi/g (1.6 x 10^{-3} Bq/g) in beef liver,
  1.2 x 10^{-2} pCi/q (4.4 x 10^{-4} Bq/q) in deer muscle (on NTS),
  2.2 x 10^{-3} pCi/g (8.2 x 10^{-5} Bq/g) in deer liver (on NTS).

- **Vegetables**

  $^{239+240}Pu$: 0.051 and 0.029 pCi/g in potatoes and summer squash from Rachel, all other vegetables range from 0.004 to 0.01 pCi/g.

The dose to an individual then is estimated from these findings by using the assumptions and dose conversion factors as described below.

6.2.2 ASSUMPTIONS

- Adult respiration rate is 8400 m^3/yr.
- Milk intake for a normal child 180 L/yr.
- Consumption of beef liver 0.5 lb/wk (11.5 kg/yr).
- An average deer has 100 lb (45 kg) of meat.

Table 6.1 Summary of Effective Dose Equivalents from NTS Operations during 1991

	Maximum EDE at NTS Boundary[a]	Maximum EDE to an Individual[b]	Collective EDE to Population within 80 km of the NTS Sources
Dose	9.4×10^{-3} mrem (9.4×10^{-5} mSv)	$8.6 \pm 0.8 \times 10^{-3}$ mrem (8.6×10^{-5} mSv)	4.2×10^{-2} person-rem (4.2×10^{-4} person-Sv)
Location	Site boundary 42 km WSW of NTS Area 12	Springdale, NV, 56 km WSW of NTS Area 12	21,700 people within 80 km of NTS Sources
NESHAP Standard	10 mrem per year (0.1 mSv per yr)	10 mrem per year (0.1 mSv per yr)	-----
Percentage of NESHAP	9.4×10^{-2}	8.6×10^{-2}	-----
Background	142 mrem (1.4 mSv)	142 mrem (1.4 mSv)	1660 person-rem (16.6 person Sv)
Percentage of Background	6.6×10^{-3}	6×10^{-3}	2.5×10^{-3}

(a) The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the NTS boundary located 42 km WSW from the Area 12 tunnel ponds.

(b) The maximum individual dose is to an person outside the NTS boundary at a residence where the highest dose-rate occurs as calculated by CAP88-PC (Version 1.0) using NTS effluents listed in Table 5.1 and assuming all tritiated water input to the Area 12 containment ponds was evaporated.

- Water consumption of 2 L/day.
- Fresh vegetable consumption of 1 lb/day for a 4-month growing season.

6.2.3 DOSE CONVERSION FACTORS

The dose conversion factors are derived from EPA-520/1-88-020 (Federal Guidance Report No. 11). Those used are:

- ^{3}H: 6.4×10^{-8} mrem/pCi (ingestion or inhalation).
- ^{90}Sr: 1.4×10^{-4} mrem/pCi (ingestion).
- ^{85}Kr: 4.0×10^{-5} mrem/yr per pCi/m^3 (immersion).
- $^{238,239,240}Pu$: 5.0×10^{-5} mrem/pCi (ingestion).
  3.1×10^{-1} mrem/pCi (inhalation).

6.2.4 DOSE CALCULATIONS

As an example calculation, the following is the result of breathing background levels of tritium in air:

- 0.5 pCi/m^3 x 8400 m^3/yr x 6.4×10^{-8} mrem/pCi = 2.7×10^{-4} mrem/yr.

However, in calculating the inhalation EDE from ^{3}H, the value is increased by 50%to account for absorption through the skin. The total dose in one year, therefore, is 4.0×10^{-4} mrem.

Considering the EDE from other pathways, the following calculations are presented:

- **Dose (CEDE) from milk consumption**

  ^{90}Sr: 0.6 pCi/L x 180 L/yr x 1.4×10^{-4} mrem/pCi = 1.5×10^{-2} mrem.

  ^{3}H: 152 pCi/L x 730 L/yr x 6.4×10^{-8} mrem/pCi = 7.1×10^{-3} mrem.

  Total = 2.2×10^{-2} mrem.

- **Dose (EDE) from breathing (measured radionuclide concentrations)**

  ^{85}Kr: 26.4 pCi/m^3 x 4.0×10^{-5} mrem/yr per pCi/m^3 = 1.1×10^{-3} mrem.

  $^{239+240}Pu$: 1.1×10^{-12} pCi/m^3 x 8400 m^3/yr x 3.1×10^{-1} mrem/pCi = 2.9×10^{-8} mrem.

  ^{3}H: from example above = 4.0×10^{-4} mrem.

  Total = 1.5×10^{-3} mrem

- **Dose (EDE) from water consumption**

  ^{3}H: 3.4 pCi/L x 730 L/yr x 6.4 x 10^{-8} mrem/pCi = 1.6 x 10^{-4} mrem.

- **Dose (CEDE) from animals and vegetable consumption (offsite)**

  $^{239+240}Pu$ in beef liver: 4.4 x 10^{-2} pCi/g x 11.5 x 10^{3} g/yr x 5.0 x 10^{-5} mrem/pCi = 2.5 x 10^{-2} mrem.

  $^{239+240}Pu$ in vegetables (at Rachel): mean = 0.04 pCi/g x 5.5 X 10^{4} g/yr x 5.0 x 10^{-5} mrem/pCi = 1.1 x 10^{-1} mrem.

  $^{239+240}Pu$ in vegetables in other locations (Worst Case) = 0.01 pCi/g which yields 2.8 x 10^{-2} mrem.

  Total (Rachel) = 1.4 x 10^{-1} mrem.

  Total (other areas) = 5.3 x 10^{-2} mrem.

6.3 ESTIMATED DOSE (CEDE) FROM RADIOACTIVITY IN A NEVADA TEST SITE DEER

The highest measured concentrations of radionuclides in deer tissue occurred in deer collected on NTS. There was 1.2 x 10^{-2} pCi/g of $^{239+240}Pu$ pCi/g in a muscle sample.

In the unlikely event that one such deer was collected by a hunter in offsite areas, the hunter's intake could be calculated. Assuming 45 kg (100 lb) of meat with this plutonium concentration, the CEDE would be:

- 1.2 x 10^{-2} pCi/g x 45 x 10^{3} g x 5 x 10^{-5} mrem/pCi = 2.7 x 10^{-2} mrem.

6.4 DOSE (EDE) FROM BACKGROUND RADIATION

In addition to external radiation exposure due to cosmic rays and gamma radiation from naturally occurring radionuclides in soil (e.g., ^{40}K, uranium and thorium daughters), there is a contribution from ^{7}Be that is formed in the atmosphere by cosmic ray interactions with oxygen and nitrogen. The annual average ^{7}Be concentration measured by the offsite surveillance network was 2.3 x 10^{-7} pCi/mL. With a dose conversion factor for inhalation of 3.2 x 10^{-7} mrem/pCi, this equates to 6 x 10^{-4} mrem, a negligible quantity when compared with the PIC network measurements that vary from 50 to 170 mR/year, depending on location.

6.5 SUMMARY

An individual with the highest calculated (modeled) EDE from exposure to NTS effluent during 1991 was a hypothetical person living at Springdale, Nevada, where the airborne inhalation dose was calculated to be 8.6 x 10^{-3} mrem, and the background gamma dose was measured (from Beatty) to be 142 mrem. If that individual additionally consumed milk, water, home

grown vegetables, beef liver, and was exposed to the average ^{3}H and ^{85}Kr concentrations in air at the assumed volumes and masses, the additional EDEs would be $2.2 \times 10^{-2} + 1.6 \times 10^{-4} + 2.8 \times 10^{-2} + 2.5 \times 10^{-2} + 1.5 \times 10^{-3} = 7.7 \times 10^{-2}$ mrem. If this individual were additionally to collect and consume an NTS deer, the estimated EDE would increase by another 2.7×10^{-2} mrem to a total possible EDE of 0.1mrem.

The 142 mrem background value is derived from an average PIC field measurement of 16.3 μR/hr at Beatty, Nevada. The dose produced from this exposure rate plus the maximal doses from food and water consumption could theoretically produce a EDE of 142 mrem plus a negligible 0.1 mrem from the ingestion and inhalation pathways to a single individual living in the Springdale, Nevada, area north of Beatty. Both the NTS and worldwide distributions contribute a negligible amount of exposure compared to natural background.

The uncertainty (2σ) for the background measurement at the 142 exposure level is approximately 2.3%. Extrapolating to the calculated annual exposure at Springdale, Nevada, yields a total uncertainty of approximately 3.3 mrem. Because the estimated dose from NTS activities is much less than 1 mrem (the lowest level for which DQOs are defined, as given in Chapter 12) no conclusions can be made regarding the achieved data quality as compared to the DQO for this insignificant dose.

Table 7.1 (Monthly Monitoring Results for NTS Potable Water Systems - 1991[a], cont.)

Area/ Building	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Area 12	Building 12-909											
RC	0.5	0.5	--	--	0.5	0.5	--	--	--	--	--	--
pH	7.5	--	--	--	8.2	--	--	--	--	--	--	--
Coliform	0	0	--	--	0	0	--	--	--	--	--	--
					PERMIT NY-5000-12NC							
Area 6	CP-65											
RC	--	0.4	0.3	0.4	--	--	0.5	--	--	--	--	--
pH	--	7.2	--	7.2	--	--	--	--	--	--	--	--
Coliform	--	0	0	0	--	--	0	--	--	--	--	--
Area 6	CP-160											
RC	--	0.4	0.6	0.4	0.5	0.5	0.4	0.6	0.8	1.0	1.0	1.0
pH	--	7.4	7.4	7.4	7.4	--	7.4	7.8	7.8	--	8.0	--
Coliform	--	0	0	0	0	0	0	0	0	0	0	0
Area 6	Area 27 Cafeteria											
RC	0.5	0.05	0.2	0.4	1.0	0.2	--	0.5	1.2	1.7	1.3	1.0
pH	7.6	--	--	7.6	--	--	--	--	--	--	--	--
Coliform	0	0	0	0	0	0	0	0	0	0	0	0
Area 6	CP-70											
RC	--	--	--	--	0.4	0.4	0.4	--	0.8	1.0	1.0	1.0
pH	--	--	--	--	8.2	--	7.6	--	--	--	8.0	--
Coliform	--	--	--	--	0	--	0	--	0	0	0	0
Area 6	Building 6-900											
RC	--	0.6	--	--	0.0	--	--	--	--	--	--	--
pH	--	7.4	--	--	8.2	--	--	--	--	--	--	--
Coliform	--	0	--	--	0	--	--	--	--	--	--	--
Area 5	Building 5-6											
RC	--	0.6	--	--	1.0	--	--	1.5	1.5	2.5	1.5	--
pH	--	7.6	--	--	8.0	--	--	--	8.2	--	--	--
Coliform	--	0	--	--	0	--	--	0	0	0	0	--
Area 5	Building 5-7											
RC	--	0.6	--	--	1.0	--	--	1.5	1.5	2.5	1.5	--
pH	--	7.8	--	--	8.0	--	--	--	8.2	--	--	--
Coliform	--	0	--	--	0	--	--	0	0	0	0	--
					PERMIT NY-5084-12NC							
Area 1	Building 1-101											
RC	0.2	--	0.8	0.5	1.0	0.1	0.2	0.1	0.5	0.4	0.2	0.2
pH	7.0	--	--	7.2	--	7.2	7.8	7.8	7.8	--	7.8	--
Coliform	0	--	0	0	0	0	0	0	0	0	0	0
Area 1	Building 1-102											
RC	--	0.3	--	--	--	--	--	--	--	--	--	--
pH	--	8.0	--	--	--	--	--	--	--	--	--	--
Coliform	--	0	--	--	--	--	--	--	--	--	--	--

(a) RC - residual chlorine in parts per million (ppm); coliform colony count is in number/100 mL

Table 7.1 (Monthly Monitoring Results for NTS Potable Water Systems - 1991[a] cont.)

PERMIT NY-4097-12NC

Area 3	Cafeteria											
RC	0.1	0.3	0.2	0.2	0.4	0.1	0.5	1.5	1.0	1.0	0.6	1.0
pH	7.2	7.8	7.4	7.6	7.8	7.6	--	8.2	8.0	8.2	7.8	8.2
Coliform	0	0	0	0	0	0	0	0	0	0	0	0
Area 3	Building 3C-65											
RC	0.1	0.2	0.2	0.2	0.2	0.1	0.5	1.5	1.0	0.5	0.6	1.0
pH	7.2	7.8	7.6	7.6	7.6	7.6	--	8.2	8.0	8.2	7.8	8.2
Coliform	0	0	0	0	0	0	0	0	0	0	0	0

(a) RC - residual chlorine in parts per million (ppm); coliform colony count is in number/100 mL

Sample results for 1991 for the distribution systems water quality parameters are listed in Table 7.1, along with applicable state of Nevada permit numbers. RC results (0.1 to 2.0 parts per million [ppm]) and pH results (6.8 to 8.4) were all within permit criteria. None of the coliform counts exceeded the reference level.

Each truck which hauled potable water from NTS wells to work areas was sampled. A total of 1134 water truck samples were collected during 1991, of which 1126 contained no coliform colonies per 100 mL sample. During July a series of coliform samples resulted in positive results as discussed in Section 3.4.

7.1.1.2 Chemical Analysis

Chemical analysis for organic and inorganic compounds was conducted in accordance with NAC 445 and 40 CFR 141. The sample collection points were at each of the nine potable water wells on the NTS shown in Chapter 4, Figure 4.3.

7.1.1.3 Volatile Organic Compound Analysis

Samples for VOCs were collected in July 1991 from all NTS potable water wells. The samples were sent to Alpha Analytical, Inc. in Sparks, Nevada, an EPA- and state-approved laboratory. One volatile organic compound, 1,1,1-trichloroethane, was detected in a sample collected from Area 6 well 4a at a concentration of 2.1 µg/L (2.1 parts per billion) which is well below the drinking water standard of 200 parts per billion. Well 4a is a recently developed well that has not been connected to a distribution system.

7.1.1.4 Inorganic Compound Analysis and Water Quality

Samples for inorganic compounds and water quality were collected in May and July, 1991, in accordance with 40 CFR 141.11 and NAC 445. These samples were sent to the state of Nevada laboratory for analysis. Sample results, along with state standards, are listed in Table 7.2.

Well 4 in Area 6 had a nitrate level of 18.2 ppm, 8.2 ppm above the National Primary Drinking Water Standard. Additional samples were collected at Well 4 which confirmed exceedance of

7.0 NONRADIOLOGICAL MONITORING

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Environmental nonradiological monitoring of NTS operations involved only onsite monitoring as there were no nonradiological discharges to the offsite environment. Onsite drinking water distribution systems were monitored for Safe Drinking Water Act compliance; sewage influents to onsite lagoons were monitored for state of Nevada permit requirements; polychlorinated biphenyl (PCB) monitoring was conducted for Toxic Substance Control Act compliance; asbestos monitoring was conducted for asbestos removal and renovation projects; and environmental media were sampled for hazardous characteristics and constituents in the vicinity of hazardous waste management sites on the NTS. Flora, fauna, and special environmental conditions were also monitored for trends and impacts.

7.1 ENVIRONMENTAL SAMPLES

7.1.1 SAFE DRINKING WATER ACT

Water sampling was conducted for analysis of bacteria, volatile organic compounds (VOCs), inorganic constituents, and water quality as required by the Safe Drinking Water Act and state of Nevada regulations. All samples were collected according to accepted practices and sent to federal- or state-approved laboratories for analysis.

7.1.1.1 BACTERIOLOGICAL SAMPLING

All drinking water distribution systems on the NTS were sampled by Reynolds Electrical & Engineering Co., Inc. (REECo). Common sampling points were rest-room and cafeteria sinks. The samples were submitted for analysis of coliform bacteria to the state-approved Associated Pathologists Laboratories in Las Vegas, Nevada. Bacteriological testing was conducted according to Nevada Administrative Code (NAC) 445.247 and 40 CFR Part 141. These require that all water systems servicing fewer than 1000 nontransient persons be tested once a month. Systems serving more persons must be tested more frequently.

Residual chlorine (RC) and pH levels were determined at the collection point by using colorimetric methods approved by the state. The results were recorded in REECo's drinking water sample logbook, and the chlorine residual level was recorded on an analysis form.

Using the "most probable number" technique, if the coliform bacteria colony count exceeded 2.2 colonies per 100-mL sample, or, using the "membrane filter" technique, if the coliform bacteria colony count exceeded zero, the system would have been declared unsafe and closed. In order to reopen the system, samples collected for three consecutive days had to have a coliform count below the state standard.

Table 7.1 Monthly Monitoring Results for NTS Potable Water Systems - 1991[a]

Area/ Building	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
						PERMIT NY-360-12C						
Area 22	Desert Rock Weather Station											
RC	0.05	0.2	0.2	0.3	0.5	--	0.3	0.5	0.5	0.2	0.1	0.2
pH	8.1	7.6	--	7.8	--	--	8.2	--	--	--	--	--
Coliform	0	0	0	0	0	--	0	0	0	0	0	0
Area 23	Building 652											
RC	0.6	0.6	0.2	0.3	0.6	0.6	0.4	0.3	0.4	0.6	0.8	0.6
pH	7.4	7.8	7.8	7.8	7.8	7.4	7.6	--	--	--	--	8.2
Coliform	0	0	0	0	0	0	0	0	0	0	0	0
Area 23	Cafeteria											
RC	0.6	0.8	0.2	0.8	0.6	0.6	0.5	0.5	0.8	0.8	0.6	0.6
pH	7.4	7.8	7.6	7.2	7.8	7.4	8.2	--	--	--	--	8.2
Coliform	0	0	0	0	0	0	0	0	0	0	0	0
Area 23	Bowling Alley											
RC	0.6	--	0.2	0.8	0.6	0.6	0.4	0.5	0.8	0.8	0.6	0.6
pH	7.4	--	7.6	7.8	8.2	7.4	7.6	--	--	--	--	8.2
Coliform	0	--	0	0	0	0	0	0	0	0	0	0
						PERMIT NY-4098-12NC						
Area 25	Site Maintenance											
RC	0.9	0.5	--	0	.5	0.2	0.4	0.1	0.5	0.2	0.7	1.0
pH	7.8	7.7	--	7.7	--	--	--	--	--	--	--	--
Coliform	0	0	--	0	0	0	0	0	0	0	0	0
						PERMIT NY-4099 12NC						
Area 2	Field Operations											
RC	0.5	--	0.2	0.2	--	0.7	0.5	0.1	0.5	0.5	0.3	0.5
pH	7.5	--	7.6	7.4	--	7.4	--	7.8	7.8	7.8	7.8	--
Coliform	0	--	0	0	--	0	0	0	0	0	0	0
Area 12	Cafeteria											
RC	0.5	--	0.2	0.3	0.5	0.6	0.5	0.5	--	0.4	--	0.5
pH	7.4	--	7.6	7.4	8.2	--	8.2	7.8	--	--	--	--
Coliform	0	--	0	0	0	0	0	0	--	0	--	0
Area 12	Building 12-30											
RC	--	0.5	--	--	--	--	--	--	--	--	--	--
pH	--	7.8	--	--	--	--	--	--	--	--	--	--
Coliform	--	0	--	--	--	--	--	--	--	--	--	--
Area 12	Building 12-12											
RC	--	0.5	0.2	0.2	--	--	0.5	0.5	0.5	0.4	0.3	0.5
pH	--	--	7.6	7.6	--	--	8.2	8.4	--	--	8.2	--
Coliform	--	0	0	0	--	--	0	0	0	0	0	0

(a) RC - residual chlorine in parts per million (ppm); coliform colony count is in number/100 mL

Table 7.2 Water Chemistry Analysis for Potable Water Wells at the NTS - 1991

		WELLS									STANDARDS	
		Army	5C	4	C	C1	J-12	J-13	8	16D	SDWA	State Limits[b]
Constituents	T.D.S.[a]	317	397	283	635	640	211	217	149	400	--	500
	Hardness	207	9	97	308	318	46	41	24	309	--	--
	Calcium	45	2	24	75	76	15	13	8	81	--	--
	Magnesium	23	1	9	30	31	9	2	1	26	--	--
	Sodium	40	137	125	41	49	50	45	30	30	--	--
	Potassium	5	6	5	13	14	5	5	3	7	--	--
	Sulfate	54	29	42	66	85	22	19	15	59	--	250
	Chloride	15	9	11	43	33	5	6	6	10	--	250
	Nitrate	1.9	8.0	18.2	1.2	0.3	9.3	9.4	6.6	0.0	10	--
	Alkalinity	214	260	126	470	478	98	100	66	292	--	--
	Bicarbonate	261	273	154	573	583	120	122	81	356	--	--
	Carbonate	0	22	0	0	0	0	0	0	0	--	--
	Fluoride	1.06	1.06	0.82	1.13	1.16	1.98	2.28	0.81	0.57	4.0	2.0
	Arsenic	0.009	0.032	0.007	0.006	0.006	0.009	0.011	<0.003	<0.003	0.05	--
	Iron	0.00	0.03	0.01	0.00	0.10	0.00	0.07	0.02	0.02	--	0.3
	Manganese	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	--	0.05
	Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	--	1
	Zinc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	--	5
	Barium	0.08	0.00	0.11	0.11	0.11	0.00	0.00	0.00	0.13	--	1
	Boron	0.2	0.5	0.2	0.7	0.7	0.1	0.1	0.1	0.2	--	--
	Silica	21	57	64	31	31	61	64	48	31	--	--
	Color	3	3	3	3	3	3	3	3	3	--	15
	Turbidity	0	0.1	0.1	0.4	0.1	0.1	0.2	0	0.1	N/A	N/A
	pH	8.10	8.84	8.13	8.16	8.13	7.91	7.84	7.92	7.82	6.5	6.5/8.5
	Elect. Conduct.	567	608	425	1049	1068	296	296	211	687	--	--
	Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	--
	Chromium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05	--
	Lead	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05	--
	Mercury	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.002	--
	Selenium	0.001	0.001	0.001	<0.001	<0.001	0.001	0.001	0.001	0.002	0.01	--
	Silver	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05	--
	MBASs	---	---	<0.1	<0.1	<0.1	<0.1	---	---	---	--	0.5

(a) Analysis for T.D.S. through Silica, and Cadmium through MBAs are measured in parts per million. Color through Electrical Conductivity are measured in standard units for each individual constituent; Gross Alpha and Gross Beta are measured in picocuries/liter (pCi/L).

(b) State primary standards are adopted directly from the SDWA standards. All standards listed are state established secondary standards.

Gross alpha and gross beta are only required every four years, next analyses due in 1994.

the standard. (see Table 7.3). Since the Area 6 Control Point Complex was supplied by this well, samples were taken to establish concentration levels at the supply points. Three samples, one taken each day a replicate sample from Well 4 was taken, reflected levels of 2.1 ppm, 1.8 ppm, and 0.9 ppm in Building CP-50. These were well below the 10 ppm standard.

Well J-13 in Area 25 had a fluoride levels of 2.28 ppm which exceeded the state of Nevada Secondary Standard of 2.0 ppm. Following 1990 sampling results that indicated elevated fluoride concentrations, the DOE petitioned the state of Nevada for a variance to fluoride requirements for wells J-12 and J-13. In January 1991 the state of Nevada approved a variance request with the caveat that the wells be sampled on an annual basis to ensure that the fluoride level does not exceed the Primary Standard of 4.0 mg/L, and that the user population would be notified of the elevated fluoride levels. The user population was initially notified in November, 1990.

Well C and Well C-1 in Area 6 had a total dissolved solids (TDS) level of 635 ppm and 640 ppm, respectively, both of which exceeded the state of Nevada Secondary Standard of 500 ppm. Additional samples for Well C-1 were collected which confirmed exceedance of the standard (see Table 7.3). Since the Area 6 Control Point Complex was supplied by these wells, samples were taken to establish concentrations levels at the supply points. Three samples reflected levels of 687, 702, and 642 ppm in Building CP-50.

Well 5C in Area 5 had a pH of 8.84, which exceed the state of Nevada Secondary Standard of a pH between 6.5 and 8.5.

Notices for posting entitled "Elevated pH in Mercury Water Supply," "Elevated Nitrate Concentration in Area 6 Water Supply,""Elevated TDS Concentration in Area 6 Water Supply," and "Elevated Fluoride Concentration in Area 25 Water Supply" were sent to the appropriate potable water user for each standard violation. These notices identified the (1) violations, (2) areas affected, and (3) potential health effects. The state of Nevada will be contacted to determine the required corrective actions.

Table 7.3 Sampling Results that Exceeded Drinking Water Standards - 1991

Well	Standard	Sample	Date	Results
J-13	Fluorides	1	7/22/91	2.28 ppm
C-1	T.D.S	1	7/22/91	640 ppm
		2	5/23/91	640 ppm
		3	1/03/91	649 ppm
		4	1/11/91	639 ppm
		5	1/17/91	164 ppm
C	T.D.S	1	5/23/91	635 ppm
		2	7/22/91	637 ppm
4	Nitrate	1	7/22/91	18.2 ppm
		2	5/23/91	17.4 ppm
		3	1/03/91	18.3 ppm
		4	1/11/91	18.3 ppm
		5	1/17/91	18.2 ppm
5C	pH	1	7/22/91	8.84

7.1.2 CLEAN WATER ACT

7.1.2.1 NTS OPERATIONS

In accordance with the state of Nevada operating permits (OPs) for the sewage lagoon systems on the NTS (OPs Nos. NV87059, NV87060, NV87069, and NV87076), regular influent sampling schedules have been established.

State-required monitoring was conducted at sewage lagoons for flow rate, pH, biological oxygen demand (BOD), and total suspended solids (TSS). The flow rate and pH were estimated or measured onsite, and the BOD and TSS were determined by the City of Henderson Laboratory, in Henderson, Nevada, a state-approved laboratory (see Table 7.4).

Continuous monitoring of flow rates was conducted at the Areas 6 (Yucca Lake), 12, and 23 lagoon systems. Flow rates were determined from periodic measurements for all other lagoon systems.

The pH was determined for the Areas 22 and 23 lagoon systems every month and for all other systems every quarter. The pH is determined through use of either a pH meter or colorimetric test strips. For BOD and TSS, the sewage lagoon system permits require biannual sampling at the Area 6 Yucca Lake and Area 25 Reactor Control lagoon systems, quarterly sampling at the Area 12 lagoon system, and monthly sampling at the Area 23 lagoon system. An automatic sampler to collect BOD and TSS samples was installed in the Area 6 Yucca Lake system during 1991.

SOLID WASTE DISPOSAL

All operation and maintenance manuals for the sanitary landfills at the NTS have been approved by the state of Nevada. (Permits are not issued for sanitary landfills by the state.) Monitoring of these landfills was limited to recording daily refuse amounts by weight. All waste disposed of in the Area 23 landfill was weighed at the Gate 100 weighing station.

Table 7.5 contains the amount of waste disposed of in the Areas 6 and 9 sanitary landfills. These estimates are based on the weight of the cargo as provided by the truck drivers.

7.1.2.2 NON-NTS SAMPLING RESULTS

EG&G/EM operations which were required by permit to sample and analyze wastewater effluent and submit monitoring reports were LVAO and WCO. The effluent monitoring demonstrated that the operations were in compliance with the limits specified in the permits.

7.1.3 TOXIC SUBSTANCES CONTROL ACT (TSCA)

During 1991, a total of 184 samples were submitted for PCB analyses. One hundred sixty-four (89 percent) of these were analyzed in-house, the other 20 (11 percent) were sent to outside commercial laboratories. Of the total number of samples, 90 were oil, 48 were swipes, 34 were water, 10 were soil, and 2 were miscellaneous "other".

The sample results are as follows: 46 oil samples did not contain any PCBs, 24 samples were less than 5 ppm (limit of quantitation), 19 samples were between 5 and 500 ppm, and 1

Table 7.4 pH, BOD, and TSS in NTS Sewage Lagoon Influents - 1991

	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			State
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Limits
pH													
Yucca Lake	—	—	7.5	—	—	7.6	—	—	7.5	7.2	—	6.9	6.0 to 9.0
Area 6, CP-6	—	—	6.5	—	—	7.2	—	—	7.0	—	—	7.6	6.0 to 9.0
Area 6, CP-72	—	—	6.5	—	—	7.3	—	—	7.5	—	—	7.8	6.0 to 9.0
Area 6 DAF	—	—	Dry	—	—	Dry	—	—	Dry	—	—	Dry	6.0 to 9.0
Area 2	—	—	7.0	—	—	7.5	—	—	7.0	—	—	7.1	6.0 to 9.0
Area 12	—	—	7.5	—	—	7.2	—	—	7.5	8.4	—	6.9	6.0 to 9.0
Area 22, Gate	8.0	7.5	7.0	8.0	8.5	7.7	8.0	8.0	8.0	8.2	7.8	8.2	6.0 to 9.0
Area 23	8.0	7.5	7.0	8.0	8.5	7.6	8.0	8.0	8.0	8.1	7.2	7.9	6.0 to 9.0
Area 25, Reactor Control	—	—	Dry	—	—	Dry	—	—	Dry	—	—	7.4	6.0 to 9.0
Area 25, Central Support	—	—	8.0	—	—	7.0	—	—	7.5	—	—	6.8	6.0 to 9.0
Area 25, Engine Test Stand	—	—	Dry	—	—	Dry	—	—	Dry	—	—	Dry	6.0 to 9.0
Area 25, Test Cell "C"	—	—	Dry	—	—	Dry	—	—	Dry	—	—	Dry	6.0 to 9.0
FLOW RATE (in millions of gallons per day)													
Area 6, Yucca Lake	0.0109	0.0092	0.0098	0.0088	0.0144	0.0059	0.0147	0.057	0.0035	0.0038	0.0023	0.0038	0.01
Area 6, CP-6	0.0062	0.0012	0.0012	0.0012	0.0012	0.0012	0.0015	0.0015	0.0015	0.0016	0.0025	0.0016	0.0078
Area 6, CP-72	0.0003	0.0005	0.0005	0.0005	0.0005	0.0005	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0006
Area 6 DAF	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.0055
Area 2	0.00007	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0009
Area 12	0.0577	0.0403	0.0524	0.049	0.061	0.053	0.071	0.0133	0.058	0.027	0.0495	0.055	0.072
Area 22, Gate	0.0010	0.0015	0.0015	0.0015	0.0015	0.0015	0.0016	0.0016	0.0016	0.0014	0.0014	0.0014	0.0015
Area 23	0.1197	0.1118	0.1365	0.154	0.112	0.130	0.163	0.143	0.152	0.117	0.111	0.114	0.227
Area 25, Reactor Control	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.0001	0.0001	0.0001	0.0015
Area 25, Central Support	0.0002	0.0001	0.0001	0.0015	0.0015	0.0015	0.0002	0.0002	Dry	0.0003	0.0004	0.0003	0.0036
Area 25, Engine Test Stand	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.0012
Area 25, Test Cell "C"	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.0008
BOD (mg/L)													
Area 6, Yucca Lake	—	—	—	242	—	—	—	—	—	132	324	—	No Standard
Area 12	—	372	—	—	—	325	—	—	216	450	342	—	No Standard
Area 23	347	503	428	352	407	342	449	219	99	150	300	251	No Standard
Area 25, Reactor Control	—	—	—	Dry	—	—	—	—	—	NS	—	—	No Standard
TSS (mg/L)													
Area 6, Yucca Lake	—	—	—	252	—	—	—	—	—	108	—	—	No Standard
Area 12	—	580	—	—	—	240	—	—	108	848	—	—	No Standard
Area 23	1700	1120	680	528	396	300	1096	540	288	220	60	320	No Standard
Area 25, Reactor Control	—	—	—	Dry	—	—	—	—	—	NS	—	—	No Standard

--- = No sampling required. Dry = No flow. NS=Flow to low for representative sampling

Table 7.5 Quantity of Waste Disposed of in Sanitary Landfills - 1991

Month	Quantity (in pounds) Area 6	Area 9	Area 23
December, 1990	36,640		
January	155,810	1,307,101	687,498
February	70,403	1,067,679	798,535
March	102,378	735,890	527,288
April	107,314	534,613	238,070
May	81,574	1,682,597	224,110
June		1,460,710	259,751
July		982,950	186,440
August		1,106,559	225,040
September		329,656	200,117
October		766,343	174,090
November		597,523	146,830

sample was greater than 500 ppm. Eighteen of the swipe samples were less than 0.87 µg/100 cm² (limit of quantitation), and the other 29 ranged from <2.88 to 126 µg/100 cm². One sample was lost in laboratory extraction. None of the 34 water samples nor 1 of the miscellaneous "other" samples indicated any PCBs. One of the miscellaneous "other" sample was less than the quantitation limit of 0.167 ppm. One soil sample analysis did not indicate any PCBs, 5 soil samples were less than the quantitation limit of 0.167 ppm, and the other 4 soil samples ranged from 0.75 to 3.1 ppm.

The laboratory also analyzed 197 (107 percent) blank and spike samples as part of the laboratory quality control program (52 percent of the total samples analyzed).

7.1.4 NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS

During 1991, 631 bulk and air samples were collected and analyzed in conjunction with asbestos removal and renovation projects at the NTS. Of the 384 bulk samples collected, 83 were positive for asbestos and 301 were negative. One hundred forty-four (27 percent) bulk quality assurance samples were also analyzed. A total of 247 general area air samples were collected and analyzed, along with 48 (16 percent) quality assurance samples.

7.1.5 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

Table 7.6 provides the number of samples analyzed during 1991 for waste management and environmental compliance activities at the NTS. One hundred eighty-eight (40 percent) of the volatile organic analyses were done in-house and the other 286 (60 percent) were performed by outside commercial laboratories. Fifty-four (53 percent) of the semi-volatile organic analyses were done in-house and the other 47 (47 percent) were performed by outside commercial laboratories. Seventeen (36 percent) of the ICP(a) metals analyses were done in-house and the other 30 (64 percent) were performed by outside commercial laboratories. One hundred thirty-nine (60 percent) of the TCLP(b) metals analyses were done in-house and the

Table 7.6 Number of RCRA Samples Analyzed - 1991

Sample Type / Analysis	Soil	Water	Sediment	Oil	Other	Total
Volatile Organic	146	153	18	102	55	474
Semi-volatile Organic	39	37	5	2	18	101
ICP Metals[a]	3	14		20	10	47
TCLP Metals[b]	126	26	20	41	20	233
pH	67	10		34	14	125
Flashpoint	24	16		78	17	135
TPH[c]	137	11		3	3	154
Other	145	4	2	74	10	235
Total	687	271	45	354	147	1504

(a) "ICP Metals" refers to samples analyzed on an inductively coupled plasma spectrometer for the presence of certain metals.
(b) "TCLP Metals" refers to samples that have been subjected to the EPA approved "toxicity characteristic leaching procedure."
(c) Total Petroleum Hydrocarbons refers to samples usually associated with underground storage tanks and fuel spills.

other 94 (40 percent) were performed by outside commercial laboratories. One hundred three (67 percent) of the TPH(c) diesel, oil, or gasoline analyses were performed in-house and the other 51 (33 percent) were performed by an outside commercial laboratory. Eighty-one (34 percent) of the miscellaneous "other" analyses were done in-house and the balance of 154 (66 percent) were performed by outside commercial laboratories. One hundred twenty-eight (95 percent) of the flashpoint analyses were performed in-house and the other seven (5 percent) were performed by an outside commercial laboratory. All of the pH analyses were performed in-house.

A total of 723 (48 percent) blank and spike samples were analyzed in the REECO Analytical Chemistry Laboratory in addition to the analyses reported in the table as part of the laboratory quality control program.

In addition, during 1991, 215 tunnel effluent and ground water characterization samples were submitted for analysis. Analyses of all of the 81 volatile organic, 69 semi-volatile organic, 62 PCBs, and 3 total petroleum hydrocarbons were performed in-house along with 256 (54 percent) blank and spike samples as part of the laboratory quality control program.

7.1.6 SPECIAL STUDIES

A total of 17 tests were conducted at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF) in 1991. These tests involved hydrogen fluoride (HF) protective suit evaluations and were conducted by Lawrence Livermore National Laboratory. Pursuant to agreement between LGFSTF and the State of Nevada, EPA provided a test panel member and field monitor at the inception of testing. These individuals participated in testing on May 1 and May 7, 1991. The EPA test monitor was positioned approximately 4.7 km (3.5 miles) downwind of the point of release, at the border between NTS and Air Force property. The air monitoring detected no

HF present at this position downwind. Additionally, no odors attributable to test chemical were noted by field monitoring personnel.

7.2 ECOLOGICAL CONDITIONS

Monitoring of the flora and fauna on the Nevada Test Site (NTS) in 1991, conducted by a group in the DOE/NV-sponsored Basic Environmental Compliance and Monitoring Program (BECAMP) (Task 3 Monitoring of the Flora and Fauna on the NTS), showed that the flora and fauna continued to be affected by a 5-yr drought. To follow the general ecological conditions at the NTS, results from the monitoring of a baseline plot in southwestern Yucca Flat that has been sampled annually since 1987 are presented. Results are also presented from the monitoring of flora and fauna on a disturbed site and the monitoring of feral horses, deer, ravens, and tortoises on the NTS.

Precipitation measured at Yucca Flat through November 1991 totaled 121 mm (4.8 inches), which is about twice the total precipitation in 1989 and 1990, respectively (Table 7.7). Precipitation in 1991 was the result of infrequent small rainfalls in early spring and thundershowers in summer.

Table 7.7 Precipitation at BJY in central Yucca Flat, 1982 - 1991.

	Precipitation
Year	Total (mm)
1982	211
1983	350
1984	276
1985	106
1986	154
1987	194
1988	114
1989	63
1990	54
1991	142

7.2.1 FLORA

Results of flora monitoring on the Yucca Flat baseline plot in 1991 showed the continued decline of perennial plants, which occurred largely before the 1991 spring rains. Many shrubs that were barely alive in July 1990 died, so that by July 1991 perennial plant populations were 74% of their 1990 level and only 40% of their 1987 level (Table 7.8). The grasses declined from 42 to 3 plants, a decrease of 93 percent. The live volume of perennial plants also continued to decline in 1991 to 94% of 1990 levels but only 59% of 1987 levels (Table 7.9). The shrubs which declined least in numbers and total live volume were the long-lived dominant species in this environment.

Table 7.8 Counts of live perennial plants by species, on a 100 m^2 baseline plot in southwestern Yucca Flat, 1987 - 1991.

Species	1987	1988	1989	1990	1991
Acamptopappus shockleyi	44	34	26	13	11
Arabis pulchra	0	1	0	0	0
Artemisia spinescens	49	47	38	21	6
Atriplex canescens	36	38	38	41	31
Ceratoides lanata	65	58	53	54	42
Ephedra nevadensis	22	18	21	21	21
Erioneuron pulchellum	28	17	0	2	0
Grayia spinosa	40	35	34	44	33
Hymenoclea salsola	11	9	8	10	8
Lycium andersonii	20	15	18	20	14
Menodora spinescens	1	1	1	1	1
Mirabilis pudica	7	4	0	0	1
*Oryzopsis hymenoides**	8	6	5	0	0
*Sitanian jubatum**	28	8	0	0	0
Sphaeralcea ambigua	71	26	2	0	1
*Stipa speciosa**	6	10	5	8	3
Tetradymia axillaris	2	2	2	2	2
Totals	438	329	251	237	175
Dead grasses			8	32	44
Dead shrubs			55	167	449

* These species are grasses; the remainder are shrubs.

The NTS desert areas support a large number of ephemeral plant species, which germinate from seed and quickly reproduce during short periods of favorable weather. In 1991 winter ephemeral plants did not germinate until mid-March, which was unusually late. They normally die in late April, but cool weather allowed their persistence and rapid growth to survive through mid-May in 1991. As a result, although numbers were low due to marginal germination conditions, growth and survival to reproduction were reasonably good everywhere, and excellent in certain patches. Results from the monitoring plot in Yucca Flat, sampled April 24, 1991 (Table 7.10), show an ephemeral plant density of 78 ± 35 individuals per square meter. Biomass at that time was about 0.5 ± 0.3 g/m^2, but nearby plots sampled two weeks later (May 6) had 1 to 2 g/m^2, the result of continuing rapid growth. Although considerably improved over 1989 to 1990 production, ephemeral biomasses and densities were much reduced from 1987 pre-drought levels.

An observation from the monitoring of the flora was the occurrence of the non-native species Russian Thistle *(Salsola australis)* across the NTS. Summer thundershowers led to occasional dense stands in August and September 1991, especially on disturbed areas. *S. australis* also did well in low numbers on undisturbed sites because the competing shrub populations were reduced by drought. The distribution of two other non-native species that are found in high densities on the NTS, the grasses *Bromus rubens and Bromus tectorum,* has been documented in a paper published in 1991 (Hunter 1991).

Table 7.9 Estimated live volumes (liters per 100 m^2) of perennial plants on a baseline plot in southwestern Yucca Flat, 1987 - 1991.

Species	1987	1988	1989	1990	1991
Acamptopappus shockleyi	592	344	381	16	41
Arabis pulchra	0	1	0	0	0
Artemisia spinescens	732	537	575	47	32
Atriplex canescens	2085	1535	1264	921	893
Ceratoides lanata	798	461	611	378	265
Ephedra nevadensis	5007	5320	5015	4482	4130
Erioneuron pulchellum	1	2	0	0	0
Grayia spinosa	2948	3195	3015	1598	1392
Hymenoclea salsola	420	196	188	44	41
Lycium andersonii	4073	3511	2681	2521	2630
Menodora spinescens	1	1	1	0	1
Mirabilis pudica	5	1	0	0	1
*Oryzopsis hymenoides**	41	10	2	0	0
*Sitanian jubatum**	11	2	0	0	0
Sphaeralcea ambigua	34	20	0	0	0
*Stipa speciosa**	2	3	3	2	1
Tetradymia axillaris	1732	1583	1869	1636	1514
Totals	18,482	16,722	15,604	11,646	10,941
Dead grasses			4	21	57
Dead shrubs			2429	3487	5184

* These species are grasses; the remainder are shrubs.

7.2.2 FAUNA

In contrast to the reduced plant production, reptiles and small mammal populations did well on the Yucca Flat plot. The nearly ubiquitous side-blotch lizard, *Ute stansburiana*, rebounded from drought-depressed levels to the same levels as 1987 (Table 7.11). Reproduction was excellent

Table 7.10 Species richness, densities and total above-ground biomasses of spring ephemerals in southwestern Yucca Flat, sampled in April, 1988-1991.

	1988	1989	1990	1991
Species (n per 1000 m^2)	21	0	0	22
Density (n/m^2)	1956 ± 557	0	0	78 ± 35
Biomass (g/m^2)	21	0	0	0.5 ± 0.3

Table 7.11 Estimated densities (n/ha) of the lizard *Ute stansburiana* in summer on a baseline plot in Yucca Flat, NTS. The error terms are estimated 2 sem following Seber (1982).

	1987	1988	1989	1990	1991
Adults	33 ± 6	42 ± 13	55 ± 11	20 ± 6	32 ± 12
Hatchlings	123 ± 18	101 ± 34	11 ± 5	53 ± 25	121 ± 25

in 1991, with 121 ± 25 hatchlings found at the August census. The excellent reproduction can be attributed to a good insect supply, a probable result of the increased ephemeral plant densities.

The resident small mammals of the desert sections of the NTS are kangaroo rats and mice. The most ubiquitous of these, Merriam's Kangaroo Rat *(Dipodomys merriami)*, increased to its highest observed densities (7.4 individuals per hectare) of the four years of monitoring (Table 7.12). The Chisel-toothed Kangaroo Rat *(Dipodomys microgas)* declined further from an already depressed level throughout the Mojave desert sections of the NTS while the Little Pocket Mouse *(Perognathus longimembris)* rebounded somewhat from drought-depressed populations.

Monitoring of feral horses on the NTS continued in 1991. Of the 64 horses identified through 1990, three were not seen in 1991 thus indicating probable death of three adults. At least 12 foals were produced of which six had disappeared by October 1. Because forage conditions were good and mares and foals appeared healthy during 1991, the foal losses were probably due to predation. Mountain lions *(Felix concolor)* were the most likely predators.

A third annual deer census was performed on Pahute and Rainier Mesas in 1991. The number of deer observed in September 1991 were slightly lower than those seen in 1990, which can be considered a depressed level (Table 7.13).

NTS raven *(Corvus corax)* populations were censused in some detail in 1991. A survey in July 1990 found there were more than 230 ravens congregated around landfills, sewage ponds, and construction camps. In July 1991, only 156 ravens were observed, a dramatic decline, due to the Area 6 landfill closure in May. In addition, 19 ravens' nests were located; two were in Joshua trees *(Yucca brevifolia)*, one was in a planted black willow tree *(Salix goodingii)* at a

Table 7.12 Estimated spring densities (n/ha) of small mammals determined by mark recapture techniques on the Yucca Flat baseline plot. The error terms are estimated 2 sem following Seber (1982).

Species	1988	1989	1990	1991
Dipodomys merriami	5.0 ± 0.2	3.4 ± 0.0	5.0 ± 1.3	7.4 ± 0.0
Dipodomys microps	5.2 ± 0.8	2.7 ± 0.7	2.3 ± 1.0	1.2 ± 0.0
Perognathus longimembris	19.0 ± 1.8	9.0 ± 1.6	8.2 ± 4.7	13.2 ± 3.5

Table 7.13 Number of deer seen per kilometer of road travelled on Pahute an d Rainier Mesas, 1989 - 1991. Error terms are standard errors of the mean, based on three sample nights.

Year	n/km
1989	0.51 ± 0.05
1990	0.34 ± 0.01
1991	0.25 ± 0.02

historical site (the Cane Springs stagecoach stop), and the rest were in man-made structures such as towers, platforms, and the roofs of abandoned buildings.

In March 1990 REECo received a permit from the U.S. Fish and Wildlife Service to capture, mark, weigh, and attach transmitters to desert tortoises *(Gopherus agassizii)* and to salvage dead animals and remains. The permit was issued for the purpose of scientific research into desert tortoise populations and habitats in order to enhance survival of the species. During 1991, 11 free-roaming tortoises were captured, weighed, marked, and released on the NTS, bringing the total marked since 1987 to 75 individuals. In addition, all 17 tortoises inhabiting fenced areas in Rock Valley were recaptured and measured in 1991. These animals have been recaptured twice a year, when possible, for the last 27 years. Early symptoms of upper respiratory tract disease (URTD) was observed in one of the above-mentioned tortoises.

7.2.3 MONITORING OF DISTURBED AREAS

One disturbed area monitored in 1991 was an eleven acre site (Waste Consolidation Site 3B) from which mounds of buried radioactive waste were removed in 1986 to 1987. Part of the waste-consolidation process involved removing all vegetation and surface soil. In 1989 this site was ripped to soften the soil and about 4,000 young saltbush shrubs (*Atriplex canescens*) were planted in revegetation trials. Plants and animals were censused on this site and an adjacent undisturbed plot in 1988, the year before planting, and again in spring and summer of 1991.

In 1988 the vegetation on Site 3B consisted solely of the ephemeral Russian Thistle *(Salsola australis)* which grows naturally on disturbed sites; there were no perennial plants on the site. By 1991 the transplanted saltbush *(Atriplex canescens)* had grown to a volume (1062 liters per 200 m^2) approximately 20 percent of the live volume on the control site. The ephemeral plants in 1991 consisted of low densities and number of plants, comprised largely of *S. australis* seedlings.

The vegetation on the control plot at Site 3B (Table 7.14) showed a similar drought-influenced trend to that of the baseline plot in Yucca Flat. Between 1988 and 1991, the live volume of perennial plants decreased by 78 percent from 23348 to 5120 liters on the 200 m^2 site. The numbers of bunch grasses had also declined from 137 to 2, a 99 percent decrease. This dramatic change was attributable to severe drought during 1989 and 1990.

Table 7.14 Vegetation characteristics of a control transect (200m^2) adjacent to the Site 3B revegetation site in 1988 and 1991.

Species	n		Live Volume Liters	
	1988	1991	1988	1991
Acamptopappus shockleyi	80	22	1372	48
Atriplex canescens	67	16	3354	326
Ceratoides lanata	80	57	1942	360
Chrysothamnus viscidiflorus	19	0	1932	0
*Ephedra nevadensis**	13	6	3270	3396
Hymenoclea salsola	2	0	8	0
Lycium andersonii	5	4	694	275
Menodora spinescens	14	13	863	444
*Mirabilis pudica**	9	12	15	205
Oryzopsis hymenoides	98	1	115	2
*Polygala subspinosa**	85	43	9	57
Sitanion jubatum	39	0	9	0
Sphaeralcea ambigua	4	0	17	0
Stephanomeria pauciflora	0	1	0	2
Stipa speciosa	0	1	0	0
Tetradymia glabrata	26	1	9604	5
Unknown	4	0	144	0
Totals	499	171	23,348	5120
Dead grasses	4	139	1	103
Dead shrubs 28	250	641	18666	

* Rhizomatous species, numbers are poorly defined.

Adult lizards had re-invaded Site 3B, occurring at about one-third the density of the control area (Table 7.15). Lizards were totally absent in 1988, but kangaroo rats *(Dipodomys* sp.) were trapped on the edges of the scraped area. Small mammal densities were about equal between 1988 and 1991 on Site 3B.

In previous studies of disturbed areas, burned areas and ground zeros, lizards generally occurred in reduced numbers on areas lacking shrub cover while some of the burrowing rodents, like Merriam's Kangaroo Rat *(Dipodomys merrriami),* were at normal densities. The lizard hatchlings, as well as the resident adult lizards, showed poor survivorship on bare areas. It is probable that predation prevents extended survival in the absence of cover. The presence of adult lizards in the 1991 spring (April and May) census on Site 3B is due to the cover of the transplanted saltbush *(Atriplex canescens)* because the ephemeral plants were too small to have provided cover.

Table 7.15 Estimated spring densities (n/ha) of lizards and small mammals on a site revegetated in 1989, and measured in 1988 and 1991 using mark-recapture techniques. Error terms are an estimated ±2 sem based on Seber, 1982.

Species	Revegetated		Control	
	1988	1991	1988	1991
Lizards				
Ute stansburiana	0	9 ± 5	80 ± 54	28 ± 9
Mammals				
Dipodomys merriami	5.2 ± 0.5	5 ± 3	11 ± 0	4.4 ± 0
D. microps	(1)*	0	4 ± 1	(1)
Perognathus longimembris	(2)	3 ± 1	13 ± 2	2.5 ± 0
Other species (3)	0	0	(10)	0

* Numbers in parentheses are actual numbers caught, too few for a density estimate.

8.0 RADIOACTIVE AND MIXED WASTE DISPOSAL

Mary E. Donahue

Two radioactive waste disposal facilities are operated on the NTS; the Area 5 Radioactive Waste Management Site (RWMS) and the Area 3 Bulk Waste Management Facility (BWMF). During 1991 the RWMS received low-level waste generated at the NTS and other DOE facilities. Waste is disposed of in shallow pits, trenches, and in deep, large-diameter augured shafts. Transuranic (TRU) wastes are stored on a curbed asphalt pad on pallets in 55 gallon drums and various assorted steel boxes pending shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico. The Area 3 BWMF is used for disposal of low-level waste that cannot be packaged for disposal at the Area 5 RWMS. Environmental monitoring included air sampling, water sampling, tritium migration studies, external gamma exposure and vadose zone monitoring for hazardous constituents. Environmental monitoring results for 1991 indicated that no measurable radioactivity from waste disposal operations was detectable away from the area of the waste facilities; however, at their boundaries trace amounts of tritium in atmospheric moisture were detected.

8.1 WASTE DISPOSAL OPERATIONS

The Radioactive Waste Management Project was established at the NTS in January 1978. Six trenches in Area 5 were opened for the disposal of radioactive waste materials from the NTS and from non-NTS facilities of the DOE. Disposal in shallow pits, trenches, large-diameter augured shafts, and subsidence craters is now accomplished at two different sites 20 kilometers (13 miles) apart; the RWMS in Area 5 and the BWMF in Area 3.

Resource Conservation and Recovery Act (RCRA) hazardous waste disposal operations at the NTS require the shipment of nonradioactive hazardous materials to licensed disposal facilities offsite. No disposal of hazardous materials was performed at the NTS except as constituents of the Rocky Flats Plant mixed waste received from December 1988 through May 1990.

8.1.1 AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

The RWMS occupies approximately 296 hectares (732 acres) of the Frenchman Flat basin in the southeastern part of the NTS. It is located in Area 5, 26 kilometers (16 miles) north of the NTS main gate. Area 5 includes much of the Frenchman Flat playa, where nuclear tests were conducted in the 1950s to determine effects of nuclear weapons on miscellaneous targets.

The Frenchman Flat basin is bounded by the Massachusetts Mountains on the north, Black Ridge and Mt. Salyer to the west, the Buried Hills and Ranger Mountains to the east, and Mercury Ridge to the south. The general surface geology in the area is alluvial sediment. The basin is filled with up to 305 meters (1000 feet) of these sediments, which have collected there from the surrounding mountains. The disposal site is located on a relatively flat alluvial fan extending southward from the Massachusetts Mountains, which lie approximately 3.3 km

(2 miles) away. In the disposal site vicinity, the slope of the terrain is two percent. To the west, the general slope is about three percent. Two shallow dry washes cut through the site from the northwest. An earthen dike has been constructed along the northern border of the RWMS to prevent water flow into the disposal area from this direction.

There are no permanent sources of surface water or water wells at the RWMS; domestic water supplies for the site are trucked in. A water table elevation beneath the RWMS was determined using a model based on the Dupuit-Forchiemer approximation and using eight known water elevations from wells located in Area 5 but outside the RWMS. The computed water table elevation is also consistent with resistivity soundings indicating that the water table is approximately 244 meters (800) feet beneath the RWMS. Preliminary modeling studies have shown the travel time from the surface to that groundwater to be thousands of years. This modeling is based on Appendix C, "Technical Guidance Manual for Calculating Time of Travel in the Unsaturated Zone," to the report "Guidance Criteria for Identifying Areas of Vulnerable Hydrology" that was produced for the U.S. EPA by the Battelle Project Management Division in 1986.

The RWMS contains the low-level waste (LLW) management unit, which is comprised of the LLW disposal units of pits and trenches, the TRU waste storage cell, and the Greater Confinement Disposal (GCD) unit(s). Of the 296 hectares (732 acres) of the RWMS, 37 hectares (92 acres) are fully fenced, posted with warning signs, and in current use for LLW waste disposal operations.

The Mixed Waste Management Unit (MWMU) is located just north of the RWMS and will be part of routine disposal operations. This area, covering approximately 10 hectares (25 acres), will contain 18 landfill cells to be used for mixed waste disposal. In May 1990 mixed waste disposal operations ceased due to EPA issuance of the Land Disposal Restrictions of RCRA for the Third Thirds Wastes. Active mixed waste disposal operations at the NTS will commence upon completion of a National Environmental Policy Act (NEPA) documentation and issuance of a state of Nevada Part B Permit.

Mixed waste and low-level waste will only be accepted for disposal from generators (onsite and offsite) that have submitted a waste application as required by NVO-325, Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements, verified compliance to NVO-325, and received DOE/NV approval of the waste stream(s) for disposal at NTS.

Wastes are usually received in DOT Type A containers such as heavy plywood boxes or 55-gallon steel drums. These are neatly stacked, and the location of each package within the stack is recorded in case retrieval is necessary. The current closure cap design consists of five layers as follows (top to bottom): a near surface layer of ground cover, a top soil layer of native material, a filter layer of sand, a drainage layer of gravel and a low permeability layer of bentonite and silt. The total thickness of the cap is approximately 6.33 meters (20 feet) above the top of the waste packages. The closure cap will be dome shaped with a 5% slope in all directions from its center.

Most of the shipments received are low specific activity contaminated materials; however, special equipment and facilities are available for handling high specific-activity gamma emitters which are received on occasion. Reusable Type B transportation containers are used to ship these materials. An inner container holding the radioactive material is removed from the shipping cask and placed in GCD shafts.

8.1.2 AREA 3 BULK WASTE MANAGEMENT FACILITY

The second disposal site is the BWMF in Area 3, which lies at an elevation of 1230 meters (4050 feet) and covers approximately 20 hectares (50 acres). It is located in a large valley bounded by mountains and the Nellis Air Force Base Bombing and Gunnery Range. Its climate and topography is similar to that of the site in Area 5. Further details regarding the BWMF are available in DOE report DOE/NV/10630-8 (Gonzalez 1989).

Onsite and offsite generated low-level waste materials which could not be packaged were disposed of at the BWMF. Much of the waste material buried there is contaminated soil and metal remaining onsite from the atmospheric testing of nuclear weapons at the NTS. Since 1988 almost 47,464 cubic meters (1,676,000 cubic feet) have been unloaded in disposal crater U3ahat. As layers of waste material have been added, waste has been covered with uncontaminated soil (obtained from below the surface of nearby areas) until the crater is filled.

Two craters, U3ax and U3bl, were filled in this manner. Between 1974 and 1988 almost 218,915 cubic meters (7,730,900 cubic feet) of contaminated material were consolidated at this location. A 2.5-meter (8-foot) cap of clean soil extending 1.2 meters (4 feet) above the grade was placed over the craters to isolate them and the waste they contain. In compliance with RCRA, a closure plan for this location has been submitted to the state of Nevada. Approval was pending at the end of December 1991.

8.2 WASTE DISPOSAL ENVIRONMENTAL MONITORING

The Reynolds Electrical & Engineering Co., Inc., (REECo) Environmental Surveillance Section is responsible for collection of samples and verifying sample results. Standard operating procedures are maintained by the REECo Environment, Safety and Health Division, Analytical Services Department (ASD). The REECo ASD Laboratory Operations Section is responsible for the analysis of the samples.

8.2.1 AIR MONITORING

At the RWMS airborne particulate material was collected at nine sites along the perimeter fence and from six sites within the fence. At the BWMF four samplers were deployed along the perimeter fence. These air samplers operate at an air flow rate of 100 liters (3.5 ft^3) per minute and are changed weekly.

The sampling media consisted of 10-centimeter (4-inch), glass-fiber filters and charcoal cartridges that were analyzed for gamma activity and gross beta. Members of the naturally occurring ^{238}U and ^{232}Th decay chains and ^{40}K were the most frequently detected isotopes but were found in very low concentrations, typically below the detection limits of the analytical instrumentation. Except for traces of tritium in atmospheric moisture,the results from air samples collected at the RWMS were not statistically different from the annual NTS average, indicating that no detectable radioactivity other than tritium was emitted into the ambient air from the RWMS.

The primary potential airborne contaminant at the RWMS is tritium. Due to its tendency to migrate with soil moisture, tritium represents the greatest possibility for human exposure at the RWMS. Nine megacuries (3.3×10^{17} Bq) have been buried at the RWMS, and special

monitoring is performed at locations that are judged to be of higher risk to operating personnel.

Samplers for tritium oxide were located with the particulate samplers. The tritium samplers consisted of a column of silica gel, a pump for drawing air through the desiccant, and a dry-gas meter to measure the sample volume. Samples were collected routinely every two weeks, during which time approximately 10 cubic meters (350 cubic feet) of air were sampled. None of the airborne tritium concentrations measured at the RWMS exceeded Derived Concentration Guides and were only slightly higher than the NTS network annual average.

8.2.2 EXTERNAL GAMMA EXPOSURES

Thermoluminescent dosimeters (TLDs) were deployed at 24 locations around the RWMS, including six TLDs around the TRU waste storage pad and one each in Pit Nos. 3 and 4 approximately 30 meters (100 feet) from the waste stacks. Another 18 TLDs were placed around the Mounds Strategic Materials (MSM) area. All TLDs were collected and analyzed quarterly. The graph in Figure 8.1 shows that the gamma exposure rates of the different areas at the RWMS are generally not statistically different from each other. The MSM area TLDs are located in a known radiological area and therefore display higher gamma exposure rates. The mean and standard deviation exposure rate for the MSM areas was 4.5 ± 2.4 mR/day. The mean and standard deviation exposure rate for the RWMS was 0.41 ± 0.31 mR/day.

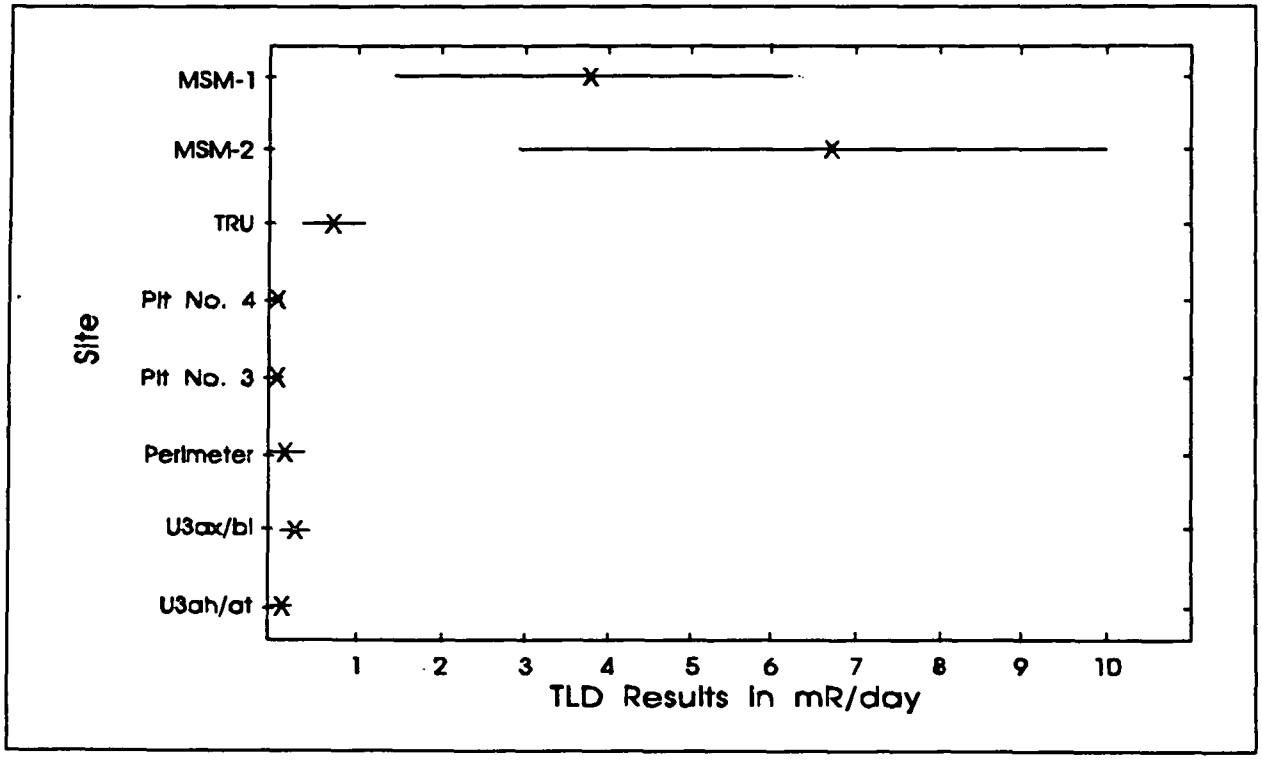

Figure 8.1 Statistical Comparison of Gamma Exposure Rates

8.2.3 WATER SAMPLING

There were forty-seven opportunities to collect precipitation water samples at both disposal sites during 1991. When samples could be collected following a precipitation event they were taken from areas of high traffic, whenever possible, and analyzed for gamma emitters. No activity above background levels was found in any of the samples taken during 1991.

8.2.4 STRATEGIC MATERIALS STORAGE AREA

Waste material from Mound Laboratory, Miamisburg, Ohio, containing approximately 290 curies (10.7×10^{12} Bq) of uranium and thorium is in temporary storage in an isolated location at the RWMS pending final disposal there. The materials are packaged in wooden boxes which in turn are stored in 28 steel cargo containers. These containers are passively ventilated through holes in the container walls. This was done to prevent the buildup of ^{222}Rn and daughters (^{218}Po, ^{214}Pb, and ^{214}Bi). In addition to the airborne alpha emitters present, accumulation of these daughters constitutes a gamma hazard. Ventilation reduces the hazards from penetrating radiations and is in keeping with the philosophy of keeping doses as low as reasonably achievable (ALARA).

The containers are located inside a fenced area that is posted with warning signs. These containers have not been opened because of the resuspendable contamination known to be present in them. TLDs were placed at 18 locations on the fence which surrounds the cargo containers and were exchanged quarterly as stated in Section 8.2.2, above.

8.2.5 VADOSE ZONE MONITORING FOR MIXED WASTE DISPOSAL

Since mixed waste consists of both hazardous and radioactive components, the monitoring method used must address both components. For this purpose a vadose zone monitoring system is being developed. Using a 24-foot grid, 24 tubes have been emplaced in Pit 3 that extend 4 meters (13 feet) beneath the floor of the pit. Each of the tubes has gas sampling ports at the top, middle and bottom of the waste stack and a sealed port 4 m (13 ft) beneath the floor. The measurements to be taken from these tubes consist of neutron logging, soil air sampling, and gamma logging. Because water movement through the unsaturated zone is the vehicle for the transport of waste components, neutron logging will be used for the long-term monitoring of soil moisture conditions within and beneath the disposal unit. Analysis of soil air samples will detect the presence and concentration of volatile organic compounds (VOCs). A gas chromatograph will be used for analyzing the EPA's CLP list of VOCs. Gamma logging will be used to identify radioactive components in the soil.

Baseline data are currently being obtained by neutron logging at 24 stations located on 8.5 meter (28 foot) centers in Pit No. 3, the interim status mixed waste cell. Gas chromatography and gamma spectroscopy data collection will begin at these same locations by the third quarter of 1992. This test area is providing data for use in computer model studies for the design of the final monitoring system.

8.2.6 TRANSURANIC WASTE STORAGE

The TRU waste storage cell was used for interim storage of TRU waste materials suspected of being TRU mixed waste materials received from Lawrence Livermore National Laboratory (LLNL). The waste is scheduled for future processing to upgrade to a WIPP certification

status. The waste is currently classified as uncertified. The waste materials are packaged in steel, fifty-five gallon drums and various size steel boxes. The waste is stored on wooden pallets, on a curbed asphalt pad, in a RCRA required configuration facilitating weekly inspections.

Neutron dosimeters were placed on the door handles of each container for the first quarter of 1991. During the second quarter the TRU waste packages were removed from the cargo containers used for storage and placed on wooden pallets. The neutron dosimetry measurements were discontinued until September when a fence was constructed around the TRU pad. The neutron dosimeters were placed on the fence near the air samplers. The fourth quarter neutron results ranged from 0.12 to 0.32 mrem/day (1.2 to 3.2 μSv/day). These results range from 0.9% to 2.3% of the occupational exposure limit should a monitored worker have been standing at the fence line for a whole day.

8.2.7 TRITIUM MIGRATION STUDIES AT THE AREA 5 RWMS

Subsurface tritium migration studies of four sites at the Area 5 RWMS have been conducted by personnel from the University of California, Berkeley.

Details of the methods and results and a discussion of the tritium migration studies are given in a topical report prepared by the University of California, Los Angeles (UCLA), REECo personnel (Schulz et al. 1991) and DOE/NV/10630-20 Volume 1. No updates on the previous reports were issued in 1991. Collection of tritium samples from Area 5 continued during 1991; however, the samples were not analyzed due the closure of the UCLA operated laboratory in Building 790.

9.0 GROUNDWATER PROTECTION

Ronald L. Hershey, and Deb J. Chaloud

DOE/NV instituted a Long-Term Hydrological Monitoring Program (LTHMP) in 1972 to be operated by the EPA under an Interagency Agreement. Groundwater was monitored on and around the NTS, at eight sites in other states, and at two off-NTS locations in Nevada in 1991 to detect the presence of any radioactivity that may be related to nuclear testing activities. No radioactivity was detected in the groundwater sampling network around the NTS. Tritium escaped in 1965 from the LONG SHOT test on Amchitka Island and contaminated the groundwater, and, during cleanup and disposal operations, shallow groundwater at the Tatum Dome Test Site in Mississippi was contaminated by tritium. The levels at both these sites are decreasing and were well below the National Primary Drinking Water Regulation levels during 1991. NTS supply wells were monitored for gross alpha and beta activity as well as tritium levels.

Because wells that were drilled for water supply or exploratory purposes are used in the present monitoring program rather than ones drilled specifically for groundwater monitoring, an extensive program of well drilling for groundwater characterization has been started. The design of the program is for installation of approximately 90 wells at strategic locations on and near the NTS.

Other activities in this program included studies of groundwater transport of contaminants (radionuclide migration studies) and nonradiological monitoring for water quality assessment and Resource Conservation and Recovery Act requirements.

9.1 HYDROGEOLOGY OF THE TESTING SITES

9.1.1 HYDROGEOLOGY OF THE NTS

The NTS has three general water-bearing units: the lower carbonate aquifer, volcanic aquifers, and valley-fill aquifers. The water table occurs variously in the latter two units while groundwater in the lower carbonate aquifer occurs under confined conditions. The depth to the saturated zone is highly variable but is generally at least 150 meters (approximately 500 feet) below the land surface and is often more than 300 meters (approximately 1000 feet). The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley Groundwater Basin (see Section 2, Figure 2.9, for a diagram of these systems). The actual subbasin boundaries are poorly defined, but the basin hydrology is summarized in the following paragraph.

Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin and discharges along a spring line in Ash Meadows, south of the NTS. Most of the western NTS is in the Alkali Flat-Furnace Creek Subbasin with discharge occurring by evapotranspiration at

Alkali Flat and by spring flow near Furnace Creek Ranch. Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley Subbasin which discharges by evapotranspiration in Oasis Valley. Some underflow from the subbasin discharge areas probably travels to springs in Death Valley. Regional groundwater flow is from the upland recharge areas in the north and east toward discharge areas in Ash Meadows and Death Valley, southwest of the NTS. Because of large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions may be radically different from the regional trend. (ERDA 1977)

9.1.2 HYDROGEOLOGY OF NON-NTS UNDERGROUND EVENT SITES (Chapman and Hokett 1991)

9.1.2.1 FALLON, NEVADA

The Shoal site is located in the granitic uplift of the Sand Spring Range. The highland area around the site is a regional groundwater recharge area, with regional discharge occurring to the west in Fourmile Flat and Eightmile Flat, and to the northeast in Dixie Valley. Evidence suggests that a groundwater divide exists northwest of the site and that the main component of lateral movement of groundwater near the site is southeast toward Fairview Valley. Groundwater in Fairview Valley moves north to the discharge areas in Dixie Valley. Groundwater in Fairview Valley occurs in three separate alluvial aquifers that are separated by clay aquitards. Calculated groundwater flow velocities through the granite to the alluvial aquifers of Fairview Valley are very slow.

9.1.2.2 BLUE JAY, NEVADA

The Faultless site is located in a thick sequence of alluvial material underlain by volcanic rocks in the northern portion of Hot Creek Valley. Recharge to the alluvial aquifer and volcanic aquifer occurs in the higher mountain ranges to the west with groundwater flowing toward the east-central portion of the valley and discharging by evapotranspiration and underflow to Railroad Valley.

9.1.2.3 AMCHITKA ISLAND, ALASKA

The groundwater system of Amchitka Island is typical of an island-arc chain with a freshwater lens floating on seawater in fractured volcanic rocks. Active freshwater circulation occurs by precipitation recharging the water table with a curving flow path downward in the interior of the island and upward flow near the coast. Generally, the hydraulic gradient is from the axis of the island toward the coast. Groundwater travel times have been estimated to be between 23 and 103 years from the test cavity to the Bering Sea.

9.1.2.4 RIO BLANCO, COLORADO

Project Rio Blanco is located 1,779 meters (5,838 feet) below the ground surface in the Fort Union and Mesa Verde Sandstones in the Piceance Creek Basin. Three aquifers comprise the majority of the groundwater resources; a shallow alluvial aquifer, the upper "A" potable aquifer, and the lower "B" saline aquifer. The A and B aquifers are separated by the Mahogany Oil Shale aquitard. These aquifers lie well above the test depth. The alluvial aquifer is the primary source of groundwater in the area with flow to the northeast toward the Piceance Creek. Recharge to the alluvial aquifer occurs by downward infiltration of

precipitation and surface water, and by upward leakage from underlying aquifers. The A aquifer is larger in areal extent than the overlying alluvial aquifer with the permeability in the A aquifer controlled by a vertical fracture system. The B aquifer exhibits minimal communication with the A aquifer.

9.1.2.5 GRAND VALLEY, COLORADO

Project Rulison is located 2,568 meters (8,426 feet) below the ground surface in the Mesa Verde Sandstone which is overlain by alluvium, the Green River Formation (shale and marlstone), the Wasatch Formation (clay and shale), and the Ohio Creek Formation (conglomerate). The direction of groundwater flow is thought to be northward. The principal groundwater resources of the area are in the alluvial aquifer which is separated from the test horizon by great thicknesses of low-permeability formations. Pressure tests of deep water-bearing zones indicted very little mobile water.

9.1.2.6 BAXTERVILLE, MISSISSIPPI

Project Dribble and the Miracle Play Program were conducted in the Tatum Salt Dome. The Tatum Salt Dome interrupts and deforms the lower units of coastal marine deposits in the area, has low permeability, and allows little water movement. Seven hydrologic units are recognized in the area, exclusive of the salt dome and its anhydrite caprock. These are, from the surface downward, the Surficial Aquifer, the Local Aquifer, and Aquifers 1, 2, 3, 4, and 5. These aquifers consist of sands and gravels, sandstones, shales, and limestones with low-permeability clay beds acting as aquitards. The natural flow has been disrupted by pumping from the upper aquifers and by injection of oil-field brines into Aquifer 5. The transient conditions and lack of data result in uncertainties in groundwater flow directions.

9.1.2.7 GOBERNADOR, NEW MEXICO

Project GASBUGGY is located on the eastern side of the San Juan Basin. The direction of groundwater movement is not well known but is thought to be to the northwest in the Ojo Alamo Sandstone toward the San Juan River. The test was conducted in the underlying Pictured Cliffs Sandstone and Lewis Shale which are not known to yield substantial amounts of water. The rate of groundwater movement in the Ojo Alamo Sandstone is estimated to be approximately 0.01 meters per year.

9.1.2.8 MALAGA, NEW MEXICO

The Gnome site is located in the northern part of the Delaware Basin which contains sedimentary rocks and a thick sequence of evaporites. The test was conducted in the halites of the Salado Formation which is overlain by the Rustler Formation, the Dewey Lake Redbeds, and alluvial deposits. The Rustler Formation contains three water-bearing zones including a dissolution residue at its base, the Culebra Dolomite, and the Magenta Dolomite. The Culebra Dolomite is the most regionally extensive aquifer in the area. The groundwater in the Culebra is saline but is suitable for domestic and stock uses. Groundwater in the Culebra flows to the west and southwest toward the Pecos River.

9.2 AREAS OF POSSIBLE GROUNDWATER CONTAMINATION AT THE NTS

A preliminary survey of underground and surface contamination at the NTS was conducted by the DOE in 1987. The survey delineated known and potential sources of groundwater contamination at the NTS including underground nuclear testing areas and surface facilities (Figure 9.1). Information from this document and from DOE/NV's "Site Specific Plan for Environmental Restoration and Waste Management, Five Year Plan," was used to describe the possible areas of groundwater contamination at the NTS. Table 9.1 is a listing of the locations on the NTS and at off-NTS sites where groundwater samples obtained from the sampling network contain detectable levels of man-made radioactivity. Potential contamination sites are discussed below.

The majority of underground tests have occurred in Yucca Flat, Frenchmen Flat, Pahute Mesa, Rainier Mesa, and Shoshone Mountain. To date, approximately 580 underground nuclear tests have been announced. The principal by-products from these tests are heavy metals and a wide variety of radionuclides with differing half-lives and decay products. Detonations within, or near the regional water table may have contaminated the local groundwater with radionuclides, principally tritium.

Surface activities associated with underground testing and the secondary missions of the NTS, including disposal of defense-related low-level radioactive and mixed wastes, spill testing of hazardous liquified gaseous fuels, testing of radioactive materials, and other activities, also pose potential soil and groundwater contamination risks. The types of possible contaminants found on the surface of the NTS include radionuclides, organic compounds, metals, hydrocarbons, and residues from plastics, epoxy, and drilling muds. A wide variety of surface facilities, such as injection wells, leach fields, sumps, waste storage facilities, tunnel ponds and muck piles, and storage tanks, may have contaminated local soil and the shallow unsaturated zone of the NTS.

Because of the great depths to groundwater and the arid climate, it is assumed that the potential for mobilization of surface and shallow subsurface contamination is minimal. However, contaminants entering carbonate bedrock from Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, and wastes disposed into subsidence craters have the potential to reach the regional water table.

9.3 GROUNDWATER PROTECTION PROGRAMS

A variety of DOE/NV programs contain some aspect of groundwater protection in their overall objectives. Descriptions of these groundwater protection activities are listed below.

9.3.1 GROUNDWATER PROTECTION POLICY AND PROCEDURES

An environmental protection policy statement for DOE/NV has been issued. A specific reference to groundwater protection at DOE/NV-managed sites is included which states, "A principal objective of the DOE/NV policy is to assure the minimization of potential impacts on the environment, including groundwater, from underground testing. To ensure minimization of impacts, while fulfilling the requirements of the testing program, the

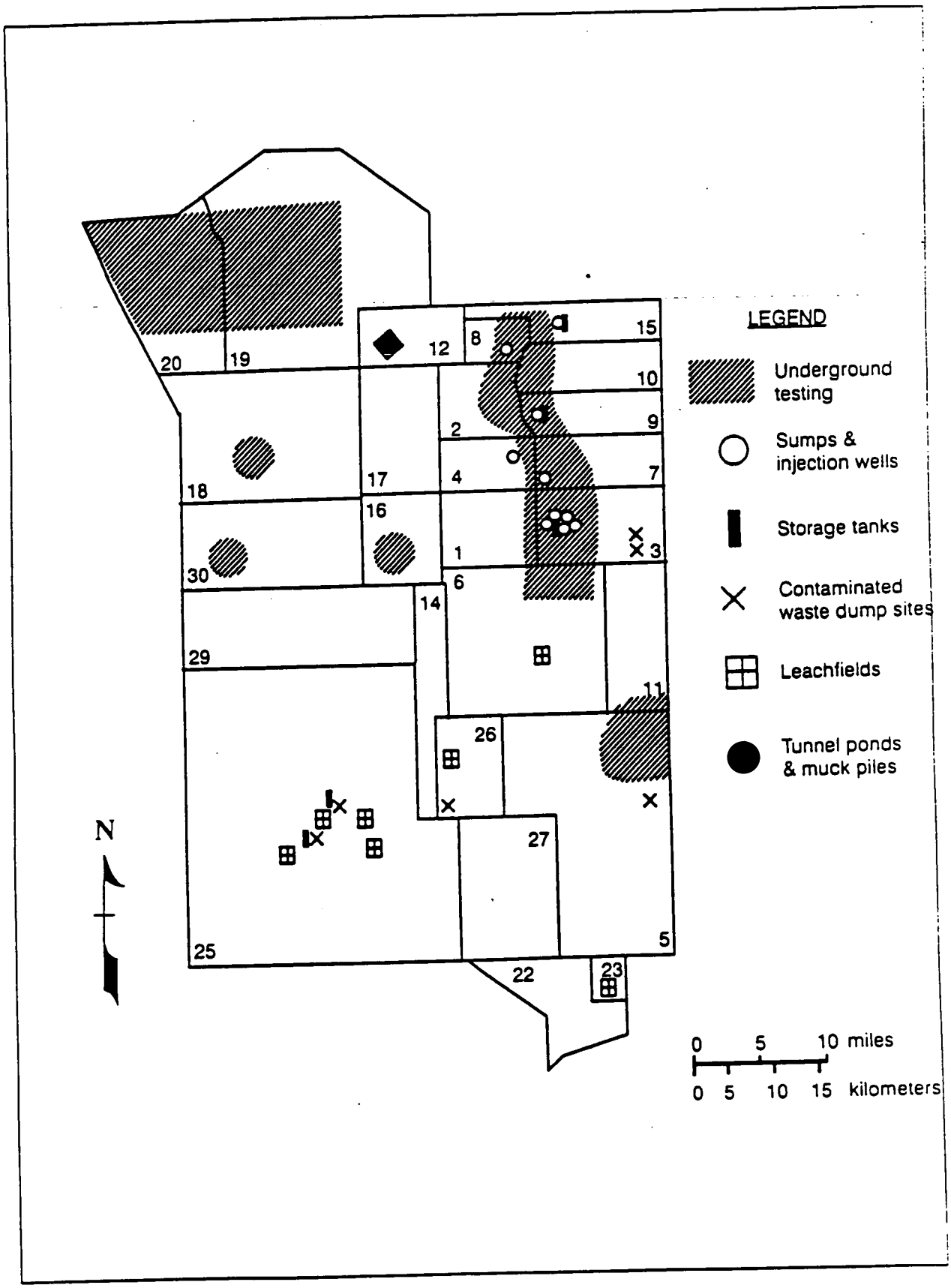

Figure 9.1 Areas of Potential Groundwater Contamination on the NTS

Table 9.1 Water Samples Containing Man-Made Radioactivity[a]

Sampling Location	Radionuclide	Concentration x 10^{-9} µCi/mL
NTS Onsite Network	None	
Project LONG SHOT, Alaska		
Well GZ No. 1	^{3}H	1.1×10^{3}
Project RULISON, Colorado		
L. Hayward Ranch	^{3}H	190
Project Dribble, Mississippi		
Well HMH-1	^{3}H	1.4×10^{4}
Well HMH-2	^{3}H	1.4×10^{4}
Well HMH-5	^{3}H	2.7×10^{3}
Well HM-L	^{3}H	1.3×10^{3}
Well HM-S	^{3}H	7.6×10^{3}
Half Moon Creek Overflow	^{3}H	280
Project GASBUGGY, New Mexico		
Well EPNG 10-36	^{3}H	480
Project GNOME, New Mexico		
Well DD-1	^{3}H	8.8×10^{7}
	^{90}Sr	1.5×10^{4}
	^{137}Cs	7.8×10^{5}
Well LRL-7	^{3}H	9.3×10^{3}
	^{90}Sr	6
	^{137}Cs	240
Well USGS-4	^{3}H	1.5×10^{5}
	^{90}Sr	6.1×10^{3}
	^{137}Cs	15
Well USGS-8	^{3}H	9.9×10^{4}
	^{90}Sr	4.5×10^{3}
	^{137}Cs	52

(a) Only ^{3}H concentrations greater than 0.2% of the National Primary Drinking Water Regulation (4 mrem) using DCGs from ICRP-30 are shown (greater than 1.8×10^{-7} µCi/mL).

location and construction of tests will be optimized in order to maximize environmental protection while minimizing adverse impacts on the testing mission of DOE/NV. An ongoing program to monitor and assess the effectiveness of groundwater protection efforts will be enhanced so that resources are allocated based on current understanding of the effectiveness of groundwater protection programs."

Procedures and controls implemented for protection of groundwater from the potential impacts of underground testing include:

- Utilizing areas previously used for testing
- Minimizing tests at or below the water table
- Restricting tests to two or more cavity radii from any regional carbonate aquifer
- Siting tests 1,500 meters or more from any NTS boundary where groundwater leaves the NTS
- Plugging of emplacement holes that extend more than two cavity radii or 30 meters beneath the working point to prevent the open borehole from becoming a preferential pathway for groundwater contamination

The Environmental Restoration and Waste Management Division of DOE/NV will review each emplacement-hole location for compliance with procedures and controls, and may make recommendations regarding acceptability of the location. Review of the emplacement-hole location documentation for technical content will include representatives of the TOD, the HRMP, and the Environmental Protection Division (EPD) of DOE/NV. The EPD will review the documentation for environmental compliance. Based on recommendations by the previously mentioned groups, additional boreholes may be required to be drilled for hydrologic monitoring. Also, if groundwater levels encountered during drilling of the emplacement holes are substantially different than predicted, the acceptability of the emplacement hole will be re-evaluated.

9.3.2 HYDROLOGY/RADIONUCLIDE MIGRATION PROGRAM

The Hydrology/ Radionuclide Migration Program (HRMP) was originally chartered to characterize the hydrologic system including the hydrogeology, groundwater chemistry, and radiochemistry beneath and around the NTS. With the initiation of the Environmental Restoration Program, the HRMP's mission and objectives are being redefined to include groundwater protection activities; development, demonstration, and transfer of new technology; hydrologic and radiologic support of operations; and long-range hydrologic research.

HRMP activities are conducted by agencies with expertise in the various sciences required to examine the subsurface effects of the weapons testing program. These agencies include the Lawrence Livermore National Laboratory, Los Alamos National Laboratory, U. S. Geological Survey, and the Desert Research Institute. A wide variety of studies, presently being conducted by the program participants are listed below.

9.3.2.1 DRILLING AND TESTING

In 1991, a hydrologic characterization well, UE-20bh#1, was drilled to make a "cradle-to-grave" hydrologic evaluation of a testing area. The well will be used to characterize local hydrologic and geologic conditions prior to an underground nuclear detonation and includes a robust completion design. If the well survives the nuclear test, it will also be used for post-test characterization and monitoring. Information gained from UE-20bh#1 will be used to study the

effects on the local hydrology and geology caused by the nuclear test and to design an effective monitoring system for potential radionuclide migration away from a test cavity. The borehole was drilled to a total depth of 856.5 meters (2,810 ft) and penetrated 183.5 meters (602 ft) below the local water table. Geophysical logging of the borehole and a step-drawdown aquifer test were conducted. Future activities at the well include a long-term aquifer test, borehole flow survey, well completion, and groundwater sampling.

9.3.2.2 SITE-SPECIFIC STUDIES

YUCCA FLAT HYDROLOGY

Unusually high hydraulic pressures are observed in Yucca Flat that present problems with respect to nuclear testing by increasing engineering and material costs and causing concern for radionuclide migration. A Yucca Flat hydrology map (groundwater altitude) is being prepared. It is to be based on historic and current groundwater levels. This long-term project is designed to collect hydraulic information necessary to understand and to mitigate problems caused by the high pressure zone in Yucca Flat. Presently, fluid levels in existing holes and exploratory holes are being monitored, and water samples are being collected for tritium, krypton, and gamma-emitting fission products. An evaluation of the information collected to date and an assessment of the potential benefits of future work is planned for 1992.

CAMBRIC STUDIES

In 1965 the CAMBRIC nuclear test was conducted in Frenchman Flat, Area 5. A re-entry borehole (RNM-1) was drilled into the cavity in 1974 along with a satellite well (RNM-2S) 91 meters away. Water has been continually pumped from the satellite well since 1974 to induce a hydraulic gradient from the cavity to the satellite well. Groundwater samples have been collected from these wells to evaluate radionuclide migration away from the cavity. All radionuclides at the cavity have decreased with time, with tritium and ^{85}Kr concentrations decreasing at similar rates. However, tritium levels have decreased slightly less than those of ^{85}Kr at RNM-2S. The apparent loss of krypton relative to tritium may be the result of sorption of krypton onto geologic material or the release of gaseous krypton to the unsaturated zone. Tritium concentrations in the cavity have decreased more rapidly relative to ^{90}Sr and ^{137}Cs. Desorption and/or dissolution of ^{90}Sr and ^{137}Cs from materials in the cavity may keep their concentrations higher than that of tritium, which exists as part of the water molecule. Effluent from RNM-2S was discharged into a ditch near the pumped well (Pumping was discontinued at the Cambric site in August in accordance with state of Nevada environmental regulations). Refinement of the mathematical model of the ditch plume wetting front is continuing. Summary reports of the migration experiments are in preparation, and data will be made available in summary form to other researchers. Additional work related to water dissipation in the unsaturated zone will continue.

PAHUTE MESA GROUNDWATER LEVELS

Two ongoing projects at Pahute Mesa are evaluating the location of water levels in emplacement holes, other boreholes, and wells. Water is often encountered in emplacement holes during drilling that is well above the predicted elevation of the local groundwater table. These waters may be perched groundwater or fluids that are introduced during drilling. A borehole-dilution test using fluoroscene dye and lithium-bromide tracer was conducted in the Bexar emplacement hole. Initial concentrations of tracer decreased approximately 25 percent over a several week period suggesting some dilution from local perched groundwater.

Chemical labeling of drilling fluids was also conducted at UE-19bh and the U-19az emplacement hole. Water-levels measurements and water sampling for tracers are continuing. Labeled drilling fluids will be monitored at several other emplacement holes to further evaluate the origin of anomalous groundwater at Pahute Mesa. Also, a groundwater altitude map of Pahute Mesa is being constructed from historic and current groundwater levels.

9.3.2.3 NEAR-FIELD HYDROLOGIC STUDY

The near-field hydrologic system controls the transfer of water and radionuclides from the shot cavity to the regional hydrologic system; therefore, it can strongly affect the environmental impact of underground testing. Theoretical studies have been made on the near-field hydrologic environment of below water-table tests. These studies have included algebraic solutions describing groundwater flow in collapse-chimney/aquifer systems, and have provided first-order estimates of potential radionuclide transport in such systems. The solutions demonstrate that the maximum potential for transport occurs when a permeable collapse chimney connects two aquifers. In such a case, pre-nuclear test vertical hydraulic gradients can drive fluids through the chimney and flush dissolved radionuclides from the chimney into one of the aquifers. Numerical models that include the effect of weapon-produced heat demonstrate that thermal buoyancy can be equally important in driving flow through the chimney. If the pre-test hydraulic gradient is upward, the likelihood of groundwater flow and transport is increased since the thermal forces tend to almost double the total driving force for vertical flow. More detailed three-dimensional modeling is being carried out, emphasizing the effect of permeability changes immediately outside the shot cavity. Estimated radionuclide transport is also being determined for several HRMP sites using the algebraic solutions for transport.

9.3.2.4 RADIONUCLIDE TRANSPORT STUDIES

When released to the groundwater system, radionuclides and toxic metals can react with various components of the groundwater, host rock, groundwater colloids, and organic compounds to form insoluble phases, solution species, and soluble complexes that can control radionuclide and metal migration behavior. Groundwater chemistry data including pH, oxidations/reduction potential, temperature, total dissolved solids, inorganic dissolved constituents, organic compounds, humic and fulvic acids, and colloids are being assembled and interpreted. Hydrochemical facies maps and cross sections are being constructed from the database. Studies to determine the nature and concentration of natural organic compounds in groundwater are being conducted. Aqueous speciation and surface-complexation of ion adsorption on rock or colloid surfaces are also being modeled using the computer code HYDRAQL.

9.3.2.5 RADIONUCLIDE DISTRIBUTION STUDIES

Some water samples from wells on the NTS have, over time, exhibited spikes of tritium which may have been the result of atmospheric or underground nuclear detonations. To evaluate these observed variations over time, parallel sampling of selected wells currently sampled in the Long-Term Hydrologic Monitoring Program is being conducted. An inventory of tritium data from NTS groundwater will be complied and a map generated showing regions of elevated tritium in groundwater.

9.3.2.6 WELL VALIDATION PROGRAM

To quantify the movement of groundwater beneath the NTS and help develop a monitoring strategy to detect the possible migration of hazardous and radioactive substances, detailed testing of existing wells and boreholes is being conducted. Wells presently used for groundwater sampling are poorly characterized with regard to lithology, aquifer penetrated, vertical hydraulic gradients, and vertical variations in water quality. Testing strategies to characterize existing well parameters have been developed and implemented. Detailed geophysical logs, borehole flow-meter logs, and water sampling were conducted at numerous boreholes. In each of these unpumped boreholes, natural vertical flow, induced by vertical hydraulic gradients, was detected. The presence of vertical flow suggests that depth-to-water measurements in open holes do not represent the actual hydraulic head present in any one open interval. The presence of vertical flow also invalidates the assumption that only horizontal flow occurs, which is traditionally used in estimating groundwater flow and contaminant transport potential.

9.3.2.7 GROUNDWATER RECHARGE STUDIES

One of the fundamental questions concerning the groundwater system at the NTS is; what are the conditions required for groundwater recharge to occur? Presently, the high-elevation areas of Pahute Mesa and Rainier Mesa are being monitored for meteorologic data, soil moisture, soil temperature, and *in situ* water content. Alluvial-wash environments are also being evaluated for their recharge potential. These data are being evaluated and will be used to construct and calibrate a groundwater recharge model.

9.3.2.8 REGIONAL GROUNDWATER MODELS

Several major activities are presently being conducted. An ongoing program to accurately determine the rate and direction of groundwater flow is being conducted. Historic water-level measurements are being evaluated and new water-level measurements are being made that describe the conditions in the water-bearing zones of the subsurface environment at and around the NTS. Water use data on and around the NTS are being collected and evaluated. A comprehensive discrete-state compartment (DSC) model of the NTS groundwater system using deuterium as a tracer has been constructed and the input parameters identified. The steady-state model has been calibrated and independently checked. Two transient-state scenarios mimicking a cooler and wetter climate have also been calibrated. Mean ages for each cell of the different scenarios were calculated and a sensitivity analysis was performed. Presently, the DSC model results are being compared to a previous model that used ^{14}C data. The models are being evaluated in terms of recharge, groundwater flow, and discharge. Stable isotopic data of rain water and groundwater are also being evaluated to investigate groundwater recharge and flow. Other naturally occurring isotopes of strontium, uranium, neodymium, hydrogen, and helium in groundwaters at the NTS are being examined to identify and trace groundwater through individual aquifers. The noble gases (helium, neon, argon, krypton, and xenon) dissolved in groundwaters are also being identified to fingerprint waters from different aquifers.

9.3.2.9 NEW TECHNOLOGIES

Significant technology development is required to economically and reliably characterize the groundwater and potential environmental contaminants in the subsurface of the NTS. New instrumentation for data collection is presently under develop by several program participants.

Some of these include new groundwater collection and water-level measurement devices; a field, downhole, infrared spectrometer to measure water content of volcanic tuffs; and, a downhole, fluid, thermal flowmeter and electrical conductivity logging tool.

9.3.3 OTHER GROUNDWATER PROTECTION PROGRAMS

9.3.3.1 WASTE MINIMIZATION

The Nevada Field Office is developing and implementing a Waste Minimization and Pollution Prevention Awareness Plan (WM&PAP) to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at DOE/NV facilities. The plan is designed to reduce the possible pollutant releases to the environment and offers increased protection to employees and the public. All DOE/NV contractors and NTS users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs that are implemented by the DOE/NV WM&PAP. Contractor programs will ensure that waste minimization activities are in accordance with federal, state, and local environmental laws, regulations, and DOE Orders. The objectives of the waste minimization and pollution program are:

- Identify processes generating waste streams
- Characterize and track each waste stream
- Identify, evaluate, and implement applicable waste minimization technologies
- Set numerical goals and schedules after the initial assessment of technological and economic feasibility
- Establish an employee pollution prevention awareness and training program

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, implementation of recycling programs, and incorporation of waste minimization concepts and technologies in planning and design of new processes, facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor and NTS user has been established to coordinate DOE/NV waste minimization and pollution prevention awareness activities.

9.3.3.2 WASTE TREATMENT, STORAGE AND DISPOSAL

DOE/NV currently operates two disposal facilities in Area 3 and Areas 5 at the NTS for low-level radioactive waste generated by DOE defense facilities (see Chapter 8). The Area 5 Radioactive Waste Management Site also serves as a temporary storage area for Lawrence Livermore National Laboratory transuranic wastes which will be shipped to the Waste Isolation Pilot Plant in New Mexico for final disposal. The Area 5 facility also accepts mixed waste, which contains both low-level radioactive waste and hazardous waste, from other DOE facilities. All hazardous waste generated at the NTS are disposed off-site at commercial facilities approved and permitted by the EPA. Hazardous wastes are temporarily stored at the NTS in full compliance with federal, state, and local requirements.

Waste disposal facilities are presently operating under interim status pending completion of the RCRA permitting process or under DOE Orders. Operation of the low-level radioactive waste and mixed waste disposal sites, and the temporary transuranic waste storage site are supported by an environmental monitoring program that indicates waste is being safely contained in the near surface environment in which it is emplaced. The radioactive and mixed-waste disposal facilities are mainly shallow land burial areas. No free liquid wastes are accepted, extensive flood protection is provided, and closure designs strongly emphasize limiting deep soil infiltration. These sites will most likely remain too dry for significant migration and consequent groundwater contamination to occur. Typical up-gradient and down-gradient monitoring wells were not employed for monitoring groundwater during 1991 in the vicinity of the disposal facility in Area 5 or other places because of the great depth and extremely long potential migration time from any contamination sites to the groundwater. Pilot wells will be installed around the Area 5 facility during 1992 to support the RCRA permitting process. Vadose zone monitoring is conducted under the waste disposal pits to obtain more timely information on any possible movement of waste constituents toward the groundwater table.

9.4 ENVIRONMENTAL RESTORATION PROGRAM

The objectives or the Environmental Restoration Program (ERP) are to assess past hazardous and radioactive waste contamination that may have occurred as a result of operations at DOE facilities, and to develop remedial actions consistent with the National Oil and Hazardous Substances Pollution Contingency Plan for those sites that pose a threat to human health, welfare, and/or the environment. Since it's inception, requirements of the ERP have been developed so that DOE compliance with federal laws such as the Resource Conservation and Recovery Act (RCRA); Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and the Superfund Amendments and Reauthorization Act (SARA) could be met. CERCLA and SARA are the primary legislation governing remedial action at former hazardous waste disposal sites and these acts require the development of a Remedial Investigation and Feasibility Study (RI/FS) to assess the potential risks present at a site and to develop and evaluate remedial actions. As a result, the ERP was modified to include a RI/FS program for all former DOE hazardous waste disposal sites and expended nuclear tests. An initial step of the RI/FS is to conduct site characterization to determine the type of contamination present, the extent and concentration of contaminants, and to identify and delineate potential contaminant transport pathways. Various aspects of the ERP and RI/FS relating to groundwater are discussed below.

9.4.1 GROUNDWATER CHARACTERIZATION PROJECT

The hydrogeologic regime in the vicinity of the NTS is not understood well enough to meet DOE's regulatory compliance objectives. As part of the ERP, the Groundwater Characterization Project (GCP) is being conducted to better understand the location, quantity, and movement of groundwater and contaminants at the NTS. Information gained from the GCP will be used in the RI/FS to evaluate potential groundwater contaminant transport pathways, the risks associated with those pathways, and possible remedial actions. Presently, the wells being drilled for the GCP are being positioned to maximize the geologic and hydrologic information available at each major underground testing area. Geologic information gained during drilling will be used to optimize testing of different hydrologic units and to determine well-screen intervals. Hydrogeologic information will be used to determine the directions and rates of groundwater flow in three dimensions, determine spatial and

temporal variations in the directions and rates of groundwater flow, and quantify parameters that control these factors.

9.4.2 TUNNEL EFFLUENT CHARACTERIZATION PROJECT

Nuclear devices are tested in horizontal tunnels mined into Rainier Mesa at the NTS. The tests are conducted in zeolitized volcanic tuffs which act as a perching layer for waters infiltrating from the mesa surface. During normal mining operations, fractures containing water are intercepted creating artificial springs in the tunnels. Periodically, these waters contain radionuclides from underground nuclear tests, and are drained out of the tunnels into evaporation ponds or washes. Mining and related operations also may have released organic compounds and heavy metals to the tunnel effluent. Presently, sampling of the tunnel effluent is being conducted to characterize the effluent. The project objectives include identifying the types and concentrations of radionuclides, metals, and organic compounds in the effluent of U12t, U12e, and U12n tunnels. Temporal variations of discharge volumes and chemical constituents are also being examined. These characterization studies are being conducted to facilitate future RI/FS activities. The RI/FS for the tunnel evaporation ponds will define the extent of the contamination, associated risks, and appropriate remedial actions.

9.4.3 OTHER ENVIRONMENTAL RESTORATION PROGRAMS

Other environmental restoration programs that involve groundwater protection include closure of NTS operational support facilities such as sumps, injections wells, and leach fields, and RI/FS activities for these facilities. Presently, waste streams are discharged to leach fields, lagoons, ponds, and sumps. An ongoing program to discontinue operations and close, or modify facilities that were previously operated in an unacceptable manner is being conducted.

Because of the arid climate and the great depths to groundwater from the land surface, any contaminants found in the near-surface environment will probably not reach the water table. However, injection of liquid wastes into wells greatly increases the potential for contamination of groundwater by shortening the pathway to the water table and supplying the medium to transport contaminants. Pumping liquid wastes into leach fields and unlined surface structures such as ponds and lagoons introduces contaminants into the unsaturated zone and supplies the mechanisms necessary to transport contaminants to the local groundwater table.

As part of the RCRA site closure process, discharges of liquid wastes to injection wells and leach fields are being eliminated. Lagoons, ponds, and sumps are being lined with impermeable materials that will allow liquid wastes to evaporate, rather than seep into the ground. Residual contaminants are being periodically removed from these surface structures. Dumping of liquid and solid, radioactive, and hazardous wastes into subsidence craters is also being eliminated. Long-term measures will be instituted to remediate contaminated areas, control migration of wastes, and/or isolate wastes from the accessible environment. A list of NTS facilities with RCRA closure plans is shown in Table 9.2.

Hazardous wastes found in the soils will be remediated as required by state of Nevada and federal regulations. Most radioactive materials produced from nuclear testing, including tritium, cannot be treated. Thus, mixed wastes and radioactive wastes presently located in the near surface will either be isolated from the accessible environment by *in situ* stabilization using engineered barriers to restrict migration or removed and placed in properly designed and permitted waste repositories. Extensive monitoring systems surrounding isolated wastes will be designed and constructed to provide early warning of contaminant migration. Dry wastes isolated in the unsaturated zone will be monitored with instruments that detect waste

transport in the liquid and gaseous phases. Monitoring systems for liquid-waste storage areas, lagoons, and ponds will also use soil-moisture and soil-gas monitoring instruments as well as monitoring wells.

Table 9.2 NTS Facilities with RCRA Closure Plans

Area	Designation
Area 2	Bitcutter Shop & LLNL Postshot Shop
Area 2	U-2bu Subsidence Crater
Area 3	U-3fi Injection Well
Area 6	Decontamination Facility Evaporation Pond
Area 6	Steam Cleaning Effluent Pond
Area 23	Building 650 Leachfield
Area 23	Hazardous Waste Trenches
Area 27	Explosive Ordnance Disposal Facility

All water-supply wells presently operating at the NTS are sampled for radionuclide contamination and hazardous contaminants where appropriate. These wells are sampled for national Safe Drinking Water Act constituents; state of Nevada drinking water constituents, and selected radioactive elements. Fourteen water wells are sampled on a monthly basis and nine drinking water consumption points are sampled on a weekly basis to ensure protection of NTS personnel. Results of sampling and analyses are discussed in section 5.2.1.6.

9.5 LONG-TERM HYDROLOGICAL MONITORING PROGRAM ACTIVITIES ON AND AROUND THE NEVADA TEST SITE

The Long-Term Hydrological Monitoring Program (LTHMP) was established in 1972 by the Nevada Operations Office of the AEC, the predecessor agency to DOE (now DOE/NV). The U.S. EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV) is responsible for operation of the LTHMP, including sample collection, analysis, and data reporting. Prior to implementation of the LTHMP, dating back to the early 1950s, monitoring of ground and surface waters was done by the U.S. Public Health Service (PHS), the predecessor agency to EPA, by the USGS, or by other AEC contractors. The LTHMP was instituted because AEC (later DOE/NV) acknowledged its responsibility for obtaining and for disseminating data acquired from all locations where nuclear devices have been tested. Those data must be appropriate and adequate to:

- Assure public safety
- Inform the public, news media, and scientific community about any radiological contamination
- Document compliance with existing federal, state, and local antipollution requirements

Under the LTHMP, routine monitoring is conducted of specific wells on the NTS and of wells, springs, and surface waters in the offsite area around the NTS. In addition, LTHMP sampling is conducted at other locations in the U.S. where nuclear weapons tests have been conducted. These locations include sites in Nevada, Alaska, Colorado, Mississippi. and New Mexico. Sites outside of the NTS and vicinity are discussed in Section 9.6.

9.5.1 SAMPLING AND ANALYSIS PROCEDURES

At nearly all LTHMP locations, the standard operating procedure is to collect three samples from each source. Two samples are collected in 500-mL glass bottles to be analyzed for tritium. The results from analysis of one of these samples are reported while the other sample serves as a backup in case of loss or as a duplicate sample. The remaining sample is collected in 3.8-L plastic container (Cubitainer). At LTHMP sites other than the NTS and vicinity, two cubitainer samples are collected. One of these is analyzed by gamma spectrometry and the other is stored as a backup or for duplicate analysis. At a few locations, because of limited supply, only 500-mL samples for tritium analysis are collected.

For wells with operating pumps, the samples are collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling rig is used. With this rig it is possible to collect three-liter samples from wells as deep as 1800 meters. At the normal sample collection sites, the pH, conductivity, water temperature, and sampling depth are measured when the sample is collected.

The first time samples are collected from a well, $^{89,90}Sr$, ^{226}Ra, and plutonium and uranium isotopes are determined by radiochemistry as time permits. Prior to 1979, the first samples from a new location were analyzed for 15 stable elements; anions, nitrates, ammoniacal nitrogen, silica; uranium, plutonium and strontium isotopes; and ^{226}Ra. Most of these analyses can still be completed by special request. At least one of the cubitainer samples from each site is analyzed by gamma spectroscopy. One of the 500-mL samples from each site is analyzed for tritium. When sample results are less than 700 pCi/L for the tritium is concentrated. The MDC for this method is approximately 10 pCi/L.

9.5.2 NEVADA TEST SITE MONITORING

The present makeup of the LTHMP for the NTS onsite network is displayed in Figure 9.2. The onsite network includes sample locations on the NTS or immediately outside its borders on federally owned land. In 1991, samples were collected monthly from 14 onsite wells and semiannually from 15 others. All of the samples are analyzed by gamma spectrometry and for tritium. For the semi-annual collections, the first set of samples is analyzed for tritium by the conventional method and the set collected about 6 months later by the enrichment method, or the sequence may be reversed. All of the onsite monthly collections are analyzed by the enrichment method. None of the sample analyses completed in 1991 exceeded the MDC of the conventional tritium analysis method. The greatest tritium activity measured in the LTHMP NTS sampling network in 1991 was 156 ± 3 pCi/L in the September sample from Well UE-18t. This activity is only 0.18% of the National Primary Drinking Water Regulation.[1] An

[1] The National Primary Drinking Water Regulation states that the sum of all beta/gamma emitter concentrations in drinking water cannot lead to a dose exceeding 4 mrem/year, assuming a person were to drink two liters of water per day for a year (40 CFR 141). Assuming tritium to be the only radioactive contaminant, the ALI in ICRP-30 yields a DCG of 9 x 10^4 pCi/L.

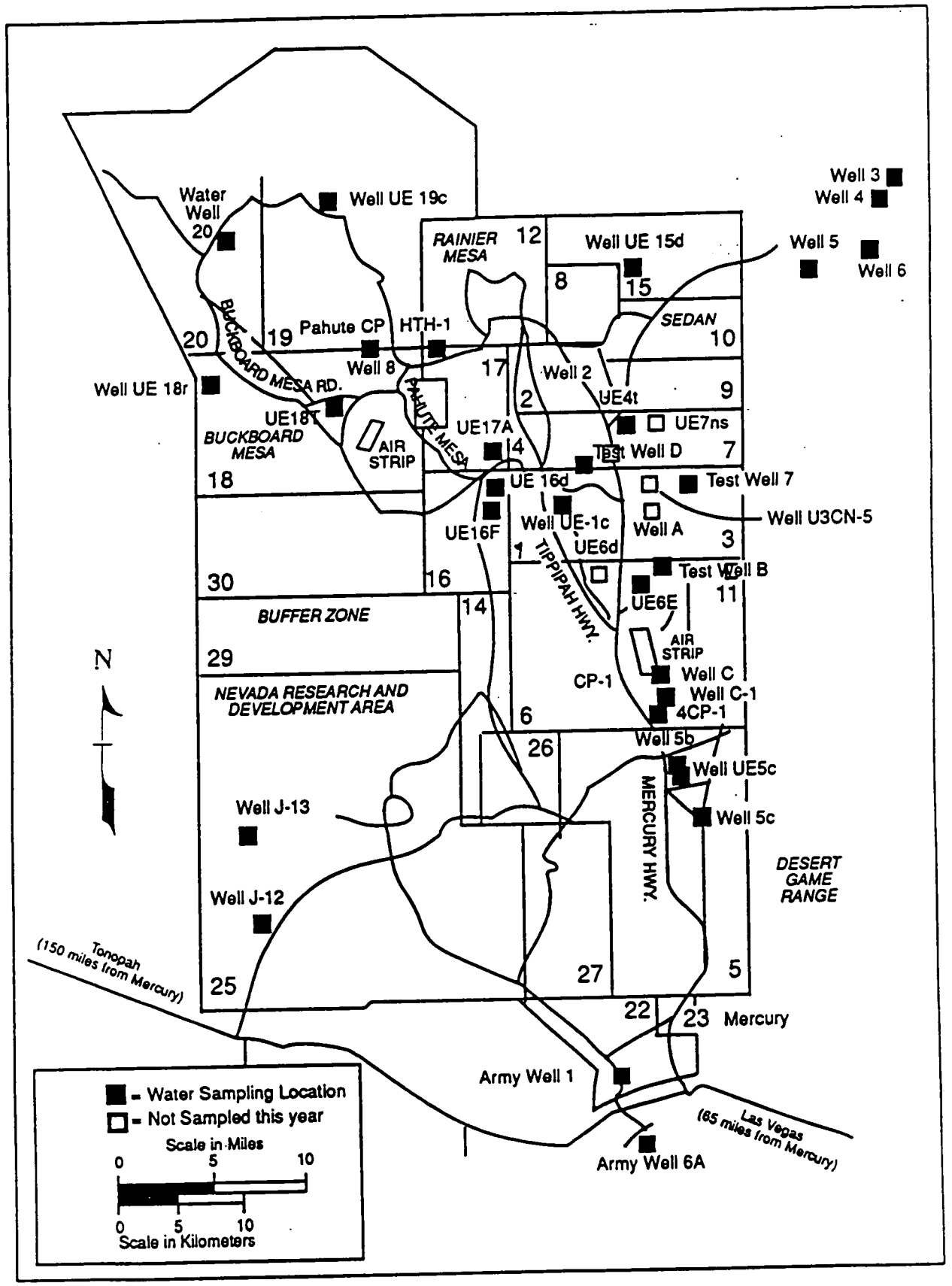

Figure 9.2 Wells on the NTS Included in the LTHMP

additional five wells could not be sampled at any time in 1991 and one well became inoperative midway through 1991. These are listed in Table 9.3. Two new wells were added in 1991; Well 6 located in the immediate offsite area near wells 3, 4, and 5 and Well UE-6d located in Area 6. Well 6 has been sampled monthly, beginning in September. Radionuclide analysis completed on the first sample collected from this well indicated the following detectable activities: 1.6 ± 0.2 pCi/L of ^{234}U, 0.063 ± 0.027 pCi/L of ^{235}U, and 0.51 ± 0.08 pCi/L of ^{238}U. Attempts were made to sample Well UE-6D in March and September, but it was not possible to collect a sample due to insufficient water in the well.

Table 9.3 Inoperative and Closed LTHMP Wells

Well Identification	Sampling Schedule	Last Sampled
Well 2	monthly	December 1990
Well 5B	semiannually	July 1988
Well 20	monthly	April 1991
Well A	monthly	October 1988
Well U-3CN#5	monthly	December 1981
Well UE-7NS	semiannually	September 1987

Twelve of the fourteen wells sampled monthly did not exhibit tritium activities exceeding the MDC of the enrichment analysis at any time during 1991. These included Well 6, added to the sampling directory in September 1991, and Well J-12 which has never yielded a detectable tritium activity; the remaining wells have been sampled for a number of years and have only on rare occasions exhibited tritium activity at detectable levels (greater than approximately 7 to 10 pCi/L). Five of the wells sampled semiannually also did not yield samples with tritium activity greater than the MDC of the enrichment method. Like the monthly sampled wells, these wells have only rarely exhibited detectable tritium activity using the enrichment analysis method. Another three of the semiannually sampled wells were only analyzed by the conventional method in 1991, with all results less than the MDC. Of these, Well UE-6E had shown tritium activities of 33 to 48 pCi/L in 1989 and 1990, Test Well 7 had only been sampled twice, in 1989 and 1991, with both samples analyzed by the conventional method, and the 1991 sample was the first sample collected from Well UE-4T.

Tritium activities greater than the MDC of the enrichment method were observed only in Test Well B and Well C in the monthly sampled sites. Test Well B averaged 115 pCi/L over 1991 (range 99 to 128 pCi/L); the long-term trend for this site indicates the tritium activity is decreasing, as shown in Figure 9.3. The average for Well C for 1991 was 23 pCi/L (range 9 to 62 pCi/L); the sampling history indicates a slightly decreasing trend consistent with tritium decay.

Tritium activities greater than the MDC of the enrichment method were also found in Well C-1, Test Well D, and wells HTH-1, UE-15D, UE-16D, UE-16F, and UE-18T in the semiannually sampled sites. The 1991 tritium activity for Well C-1 was 22 ± 4 pCi/L and was the first time a result greater than the MDC had been obtained since 1983, although the long-term sampling history indicates greater-than-MDC tritium activities have occasionally been observed. The

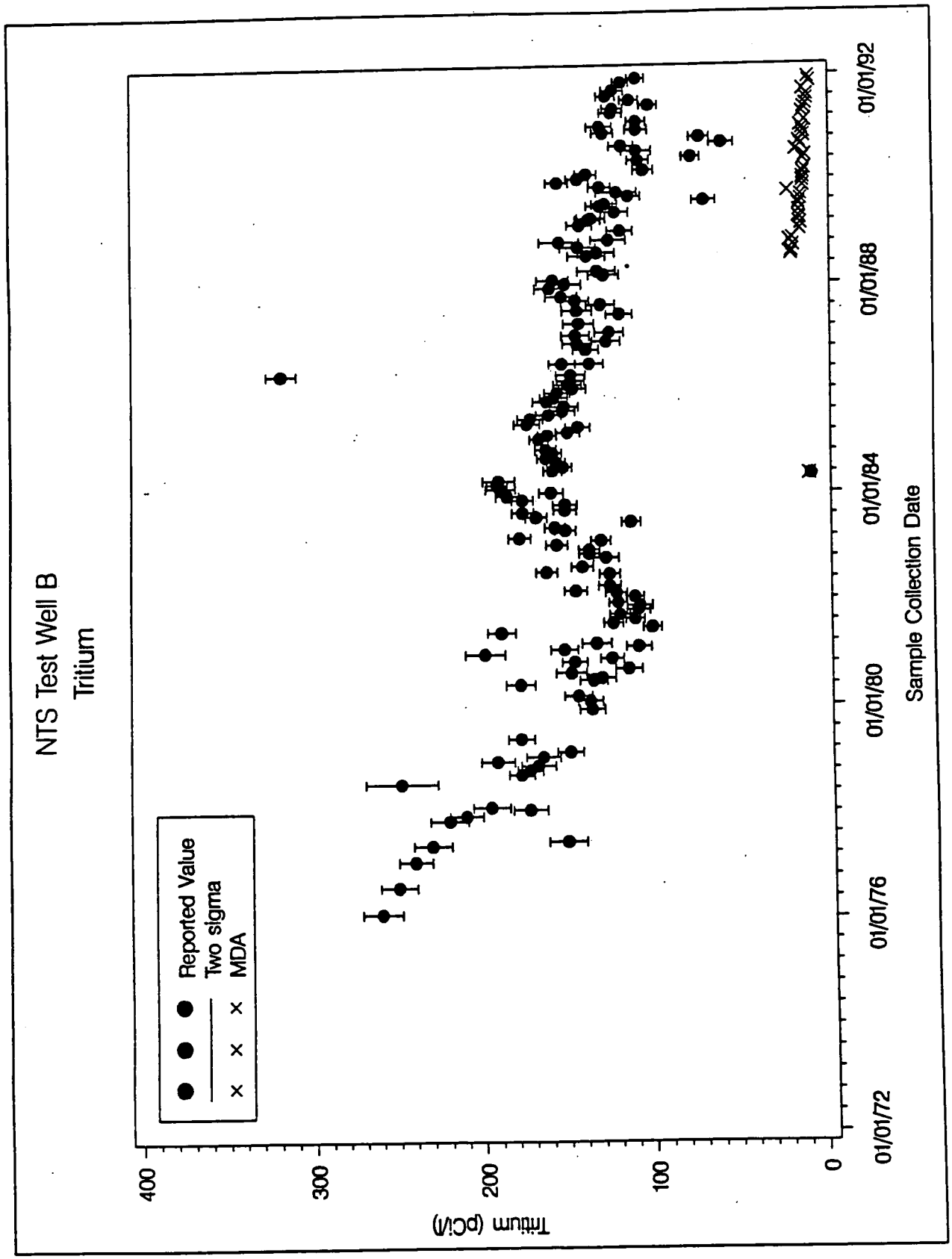

Figure 9.3 Decreasing Trends of Tritium Concentration in Test Well B, NTS

result for Test Well D was 7.6 ± 2.3 pCi/L, which was only slightly greater than the MDC of 7.4 pCi/L. Like Well C-1, Test Well D results had not exceeded the MDC of the tritium enrichment analysis since 1983, although greater-than-MDC results had occasionally been obtained in the years prior to 1983. Both of the samples collected from Well HTH-1 were analyzed by the enrichment method. The June sample was below the MDC and the December sample was 35 ± 2 pCi/L. Sampling of this well was initiated in 1989; tritium activity in the June 1990 sample was similar to that observed in the December 1991 sample, although the number of data points is insufficient to discern any trend. The May 1991 tritium result for Well UE-16D was 31 ± 3 pCi/L and was the first time that this well has displayed a detectable tritium activity since sampling began in 1982. The second sample from Well UE-16D, collected in November 1991, was also analyzed for tritium by the enrichment method with a result less than the MDC. Both samples collected from Well UE-16F in 1991 were analyzed for tritium by the enrichment method. The May 1991 sample showed tritium activity of 11 ± 3 pCi/L and the tritium activity in the November 1991 sample was 10 ± 2 pCi/L. These were the first detectable tritium activities observed at Well UE-16F since sampling began in 1989. The sample collected in April from Well UE-15D yielded a tritium activity of 76 ± 3 pCi/L; the sampling history for this well indicates high variability in tritium activity, ranging from below the MDC to greater than 100 pCi/L. Sampling at Well UE-18T has only been conducted since 1989, thus, only three analyses of tritium by the enrichment method have been completed. The 1991 result was 156 ± 3 pCi/L, the highest tritium activity measured in any of the LTHMP samples from the NTS onsite network in 1991. This result is approximately 0.18 percent of the National Primary Drinking Water Regulation. The results for all samples are provided in Tables D.4 and D.5, Appendix D, of this report.

9.5.3 OFFSITE MONITORING IN THE VICINITY OF THE NEVADA TEST SITE

The monitoring locations in the offsite area around the NTS are shown in Figure 9.4. Most of the sampling locations represent drinking water sources for rural residents in the offsite area and public drinking water supplies in most of the communities in the area. The sampling sites include 22 wells, seven springs, and two surface water sites. Twenty-nine of the locations are routinely sampled every month. The remaining two sites, Penoyer Well 13 and Penoyer Wells 7 and 8, are in operation only part of the year; samples are collected whenever the wells are in operation. Cubitainer samples are collected each month for gamma spectroscopy analysis. Samples for tritium analysis are collected on a semiannual basis. One of these semiannual tritium analyses is done by the conventional analysis method; the other is analyzed by the enrichment.

Most of the sites have rarely yielded detectable tritium levels (greater than approximately 7 to 10 pCi/L) over the last decade. Only three sites have evidenced detectable tritium activity on a relatively consistent basis. These three sites are in Nevada, namely, Lake Mead Intake (Boulder City), Adaven Springs (Adaven), and Specie Springs (Beatty). In all three cases, the tritium activity has been generally decreasing over time. The 1991 samples for Specie Springs were less than the MDC as shown in Figure 9.5.

In 1991, only four of the samples analyzed for tritium by the enrichment method yielded detectable tritium activities. These were the February sample from the Shoshone Spring, California, and three samples from Nevada: the January sample from Adaven Spring, and two samples from the Lake Mead Intake collected in September and October. The Adaven Spring result of 27 ± 4 pCi/L (0.03 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30) was consistent with the generally decreasing trend observed at this site

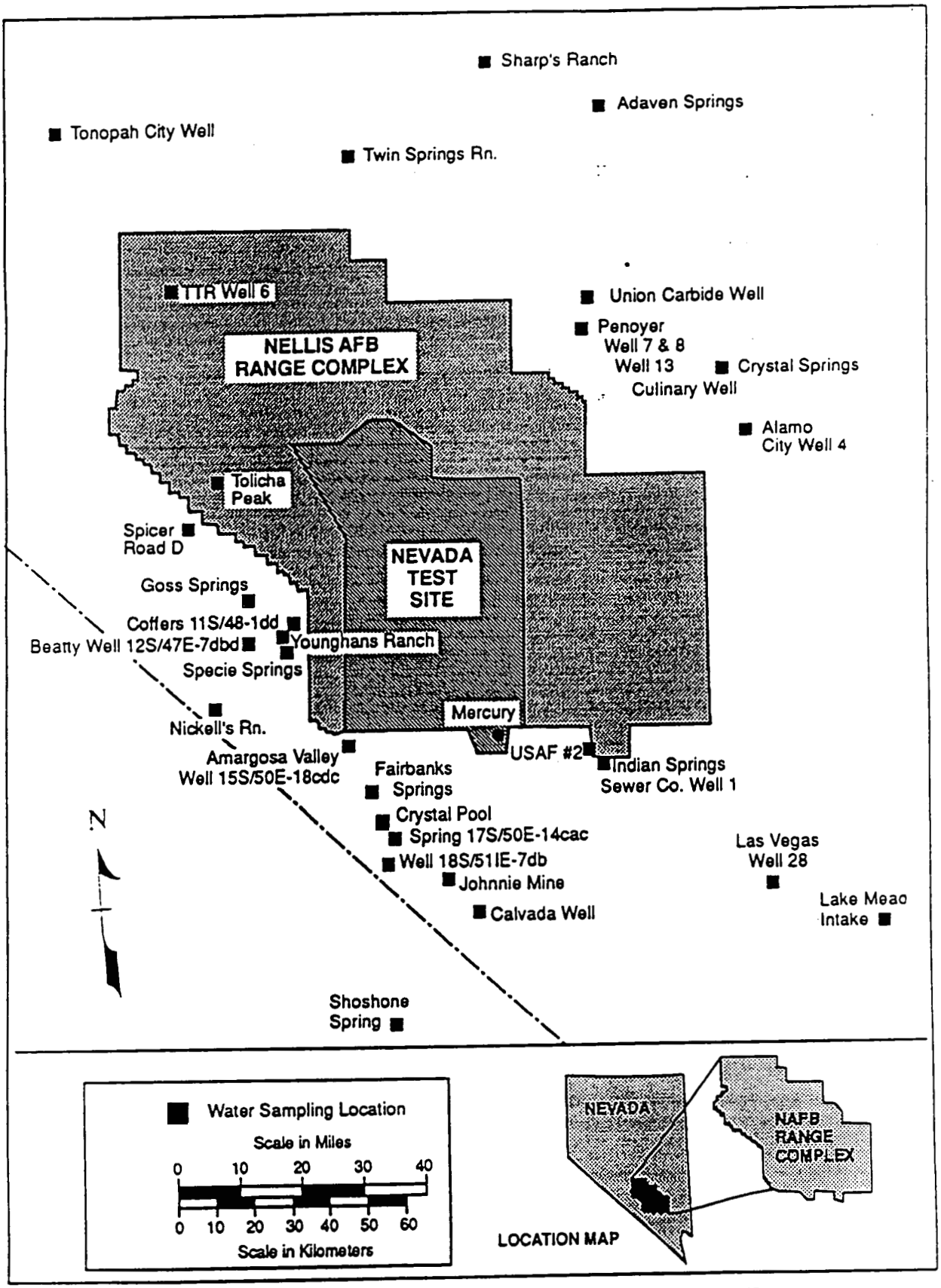

Figure 9.4 Wells Outside the NTS Included in the LTHMP

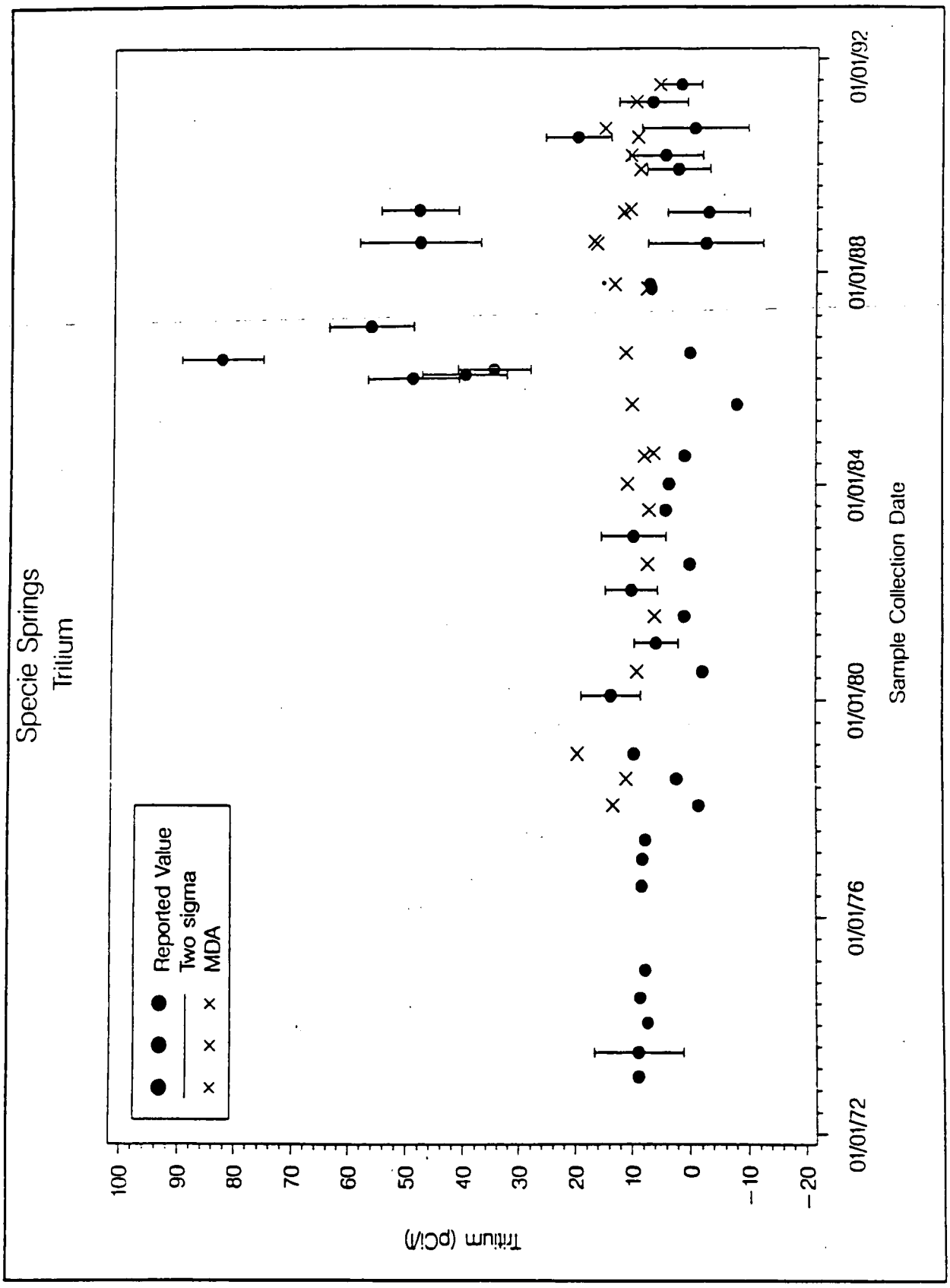

Figure 9.5 Trend of Tritium Results in Water from Specie Spring, Beatty, Nevada

as shown in Figure 9.6. Tritium has occasionally been observed at detectable levels in Shoshone Springs, CA, samples, but a consistent trend is not evident. The 1991 result was 33 ± 3 pCi/L, which is less than 0.04 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30. The results for the Lake Mead Intake were 69 ± 3 pCi/L and 65 ± 2 pCi/L for September and October, respectively. These results, which are less than 0.1 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30, were greater than results obtained in 1990, as indicated in Figure 9.7. This surface water site may be impacted by rainfall containing scavenged atmospheric tritium to a greater extent than the well and spring sites in the offsite network. Analytical results for all samples are shown in Table D.6, Appendix D.

9.6 HYDROLOGICAL MONITORING AT OTHER UNITED STATES NUCLEAR DEVICE TESTING LOCATIONS

In addition to the groundwater monitoring conducted on and in the vicinity of the NTS, monitoring is conducted under the LTHMP at sites of past nuclear device testing in other parts of the U.S. Annual sampling of surface and ground waters is conducted at the Projects SHOAL and FAULTLESS sites in Nevada, the Projects GASBUGGY and GNOME sites in New Mexico, the Projects RULISON and RIO BLANCO sites in Colorado, and the Project DRIBBLE site in Mississippi. Additionally, sampling is conducted every two years on Amichitka Island, Alaska, site of Projects CANNIKIN, LONG SHOT, and MILROW. The primary purposes of this portion of the LTHMP are to ensure the safety of public drinking water supplies and, where suitable sampling points are available, to monitor any migration of radionuclides from the test cavity. The following subsections summarize results of sampling conducted in 1991; analytical results for all samples are provided in Appendix D.

The sampling procedure is the same as that used for sites on the NTS and offsite areas (described in Section 9.5.1), with the exception that two 3.8-L samples are collected in cubitainers. The second sample serves as a backup or as a duplicate sample. Because of the variability noted in past years in samples obtained from the shallow monitoring wells near Project DRIBBLE ground zero (GZ), the sampling procedure was modified. A second sample is taken after pumping for a specified period of time or after the well has been pumped dry and permitted to refill with water. These second samples may be more representative of formation water, whereas the first samples may be more indicative of recent area rainfall.

9.6.1 PROJECT FAULTLESS

Project FAULTLESS was a "calibration test" conducted on January 19, 1968, in a sparsely populated area near Blue Jay Maintenance Station, Nevada. The test had a yield of less than 1 Mt and was designed to test the behavior of seismic waves and to determine the usefulness of the site for high-yield tests. The emplacement depth was 3200 ft. A surface crater was created, but as an irregular block along local faults rather than as a saucer-shaped depression.

Sampling was conducted on March 19, 1991. Sampling locations are shown in Figure 9.8. Routine sampling locations include one spring and five wells of varying depths. All of the sampling locations are being used as, or are suitable for, drinking water supplies. At least two

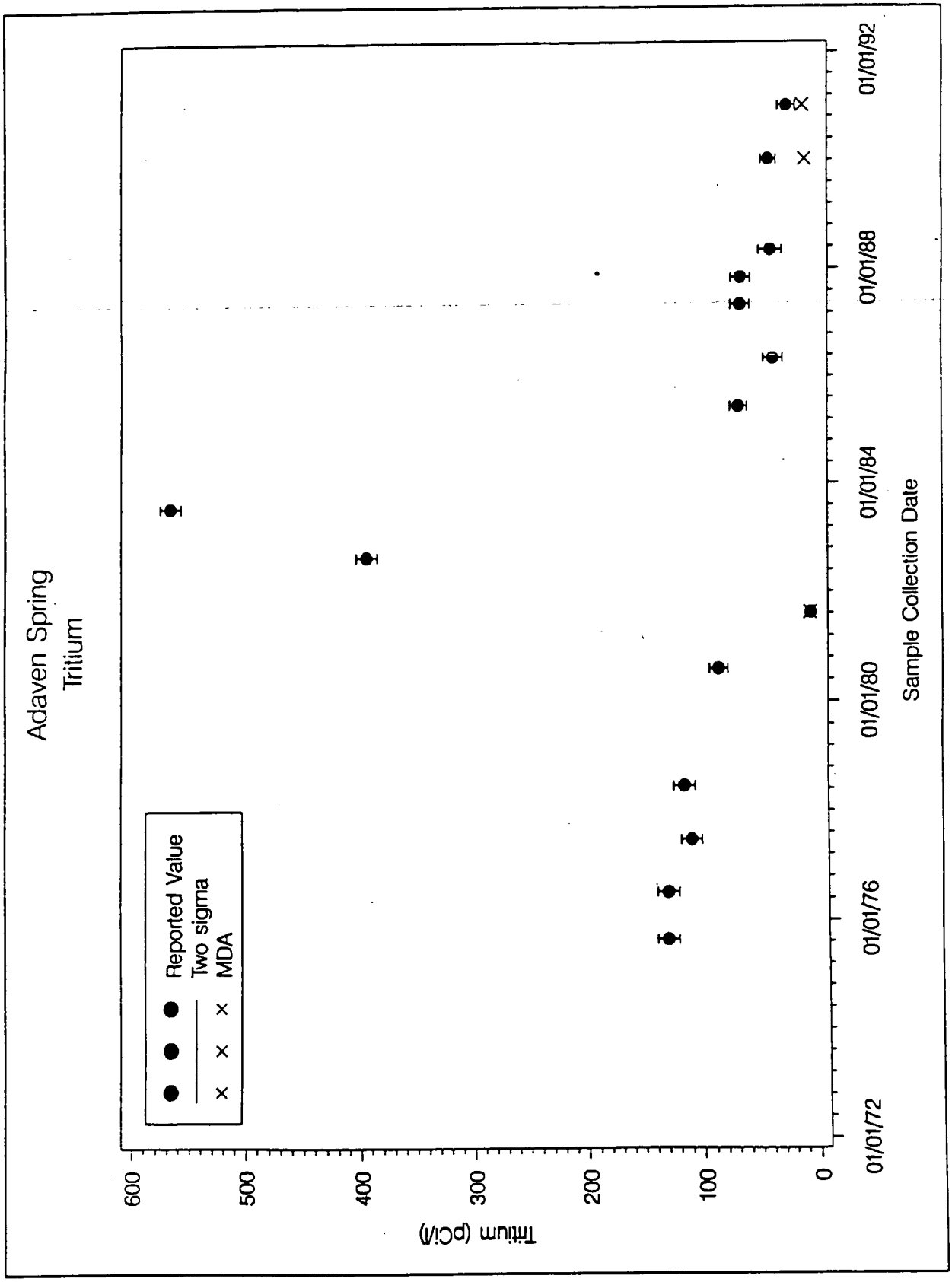

Figure 9.6 Tritium Results in Water from Adaven Springs, Nevada

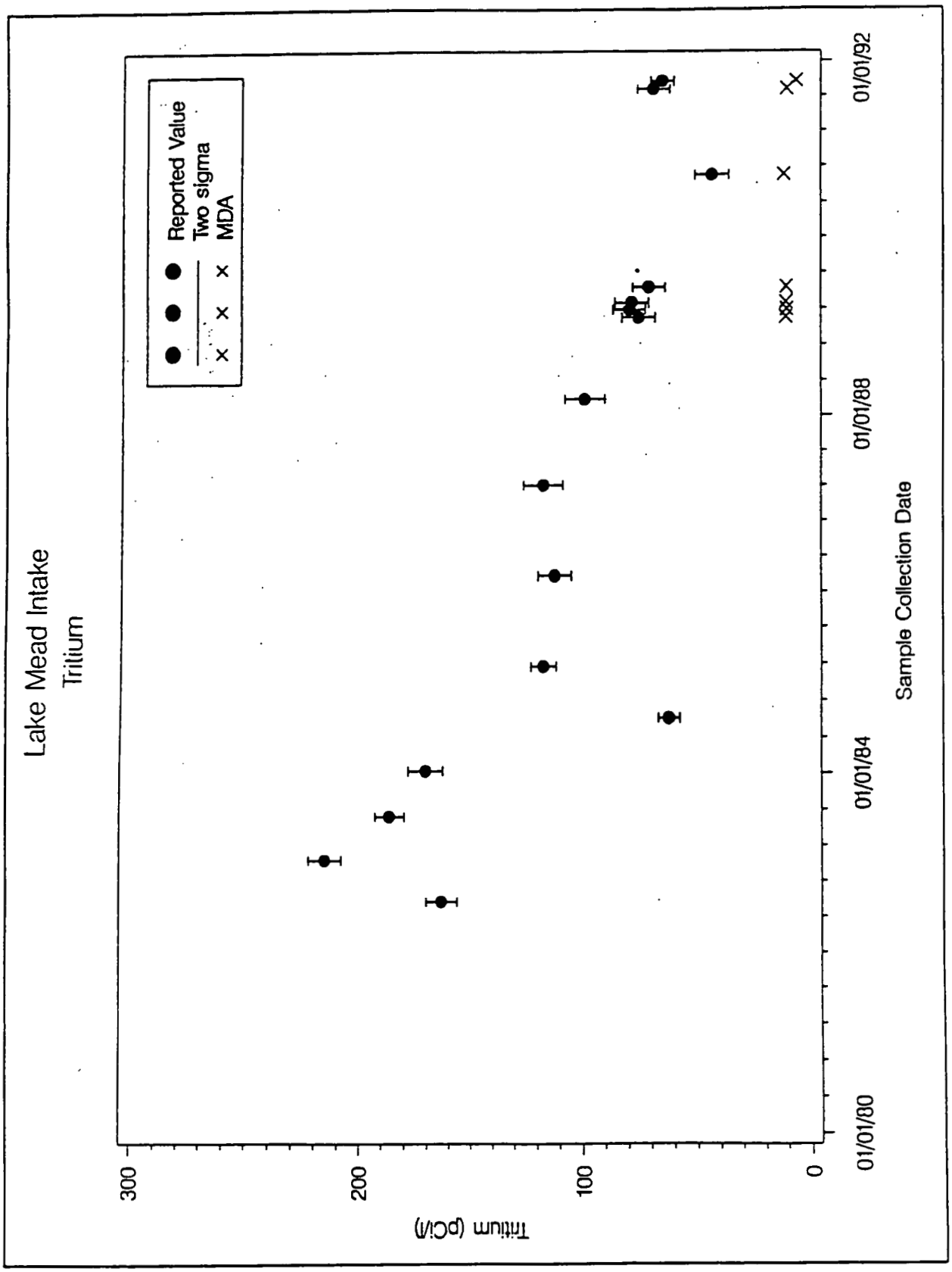

Figure 9.7 Trend of Tritium Results in Water from Lake Mead, Nevada

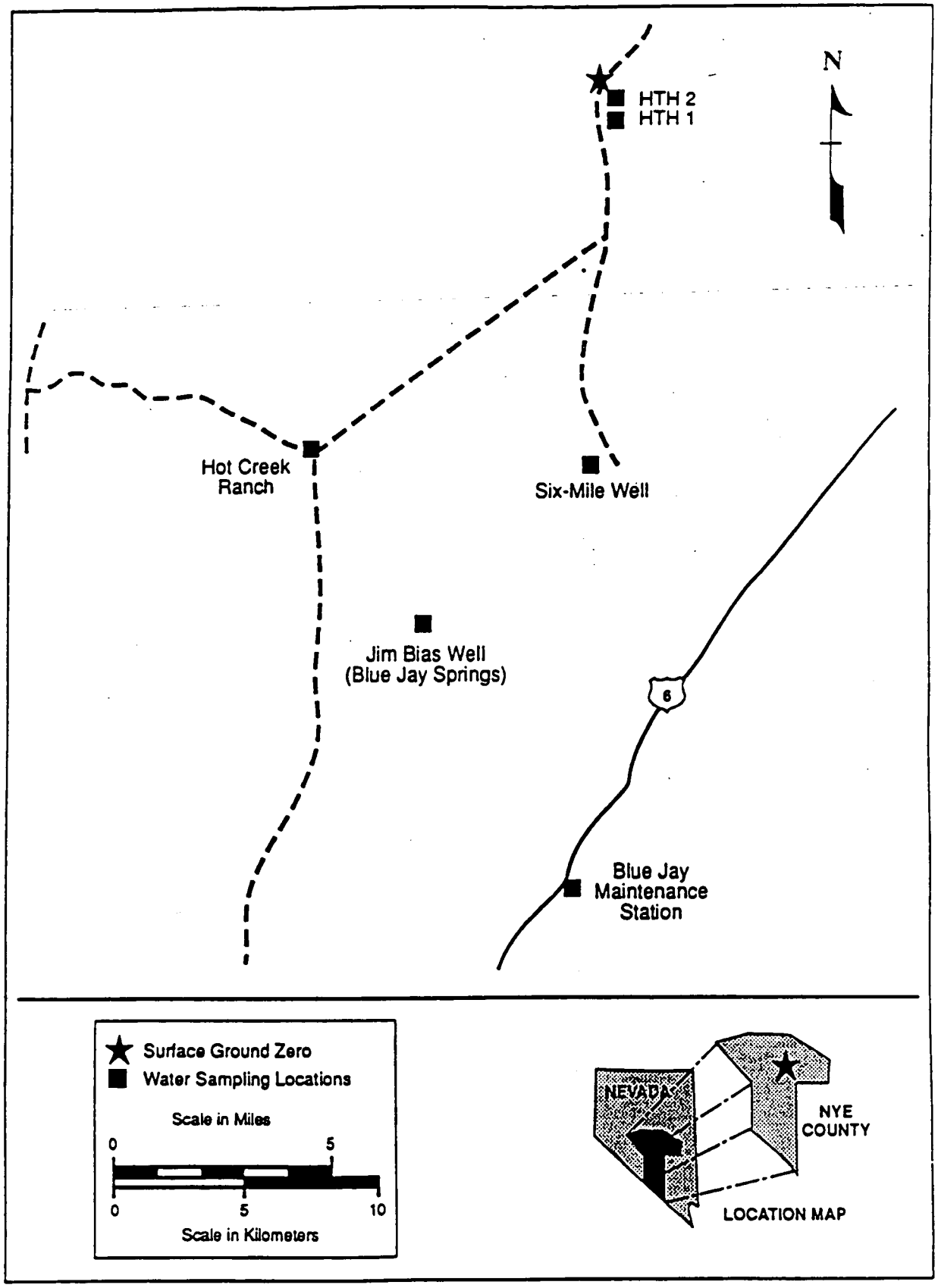

Figure 9.8 LTHMP Sampling Locations for Project FAULTLESS - 1991

wells (HTH-1 and HTH-2) are positioned to intercept cavity migration, should it occur (Chapman and Hokett, 1991). All samples yielded negligible gamma spectra and tritium activities were less than the MDC and less than 0.01 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30 (Table D.7, Appendix D). These results are consistent with results obtained in previous years. The consistently below-MDC results for tritium indicate that, to date, migration into the sampled wells has not taken place and no event-related radiation has entered area drinking water supplies.

9.6.2 PROJECT SHOAL

Project SHOAL, a 12-kt test emplaced at 1200 ft, was conducted on October 26, 1963, in a sparsely populated area near Frenchman Station, Nevada. The test, a part of the Vela Uniform Program, was designed to investigate detection of a nuclear detonation in an active earthquake zone. The working point was in granite and no surface crater was created.

Samples were collected on February 12 and 13, 1991. Five of the six routine sampling locations shown in Figure 9.9 were sampled. No sample was collected from Well H-3 because the pump was not operational. The routine sampling locations include one spring, one windmill, and four wells of varying depths. At least one location, Well HS-1, should intercept cavity migration, should it occur (Chapman and Hokett, 1991). A tritium result of 67 ± 3 pCi/L was detected in the water sample from Smith/James Spring; all of the remaining samples yielded tritium results less than the MDC. The result for Smith/James Springs is consistent with values obtained in previous years as shown in Figure 9.10. It is unlikely that the tritium source is the Project SHOAL cavity; the most probable source is assumed to be rainwater infiltration. The 1991 tritium results are 0.1 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30 for Smith/James Spring and less than 0.01 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30 for the remaining sampling locations (see Table D.8, Appendix D).

9.6.3 PROJECT RULISON

Cosponsored by AEC and Austral Oil Co. under the Plowshare Program, Project RULISON was designed to stimulate natural gas recovery in the Mesa Verde formation. The test, conducted near Rifle, Colorado on September 10, 1969, consisted of a 43-kt nuclear explosive emplaced at 8426 ft depth. Production testing began in 1970 and was completed in April 1971. Cleanup was initiated in 1972 and wells were plugged in 1976. Some surface contamination resulted from decontamination of drilling equipment and fallout from gas flaring. Soil was removed during the cleanup operations.

Samples were collected on June 11, 1991, with collection of nine samples in the area of Grand Valley and Rulison, Colorado. Routine sampling locations, depicted in Figure 9.11, include the Grand Valley municipal drinking water supply springs, water supply wells for five local ranches, and three sites in the vicinity of GZ, including one test well, a surface-discharge spring, and a surface sampling location on Battlement Creek. An analysis of the sampling locations performed by Desert Research Institute (DRI) indicated that none of the sampling locations are likely to detect migration of radionuclides from the test cavity (Chapman and Hokett, 1991).

Tritium has never been observed in measurable concentrations in the Grand Valley City Springs. All of the remaining sampling sites evidence detectable levels of tritium, which have

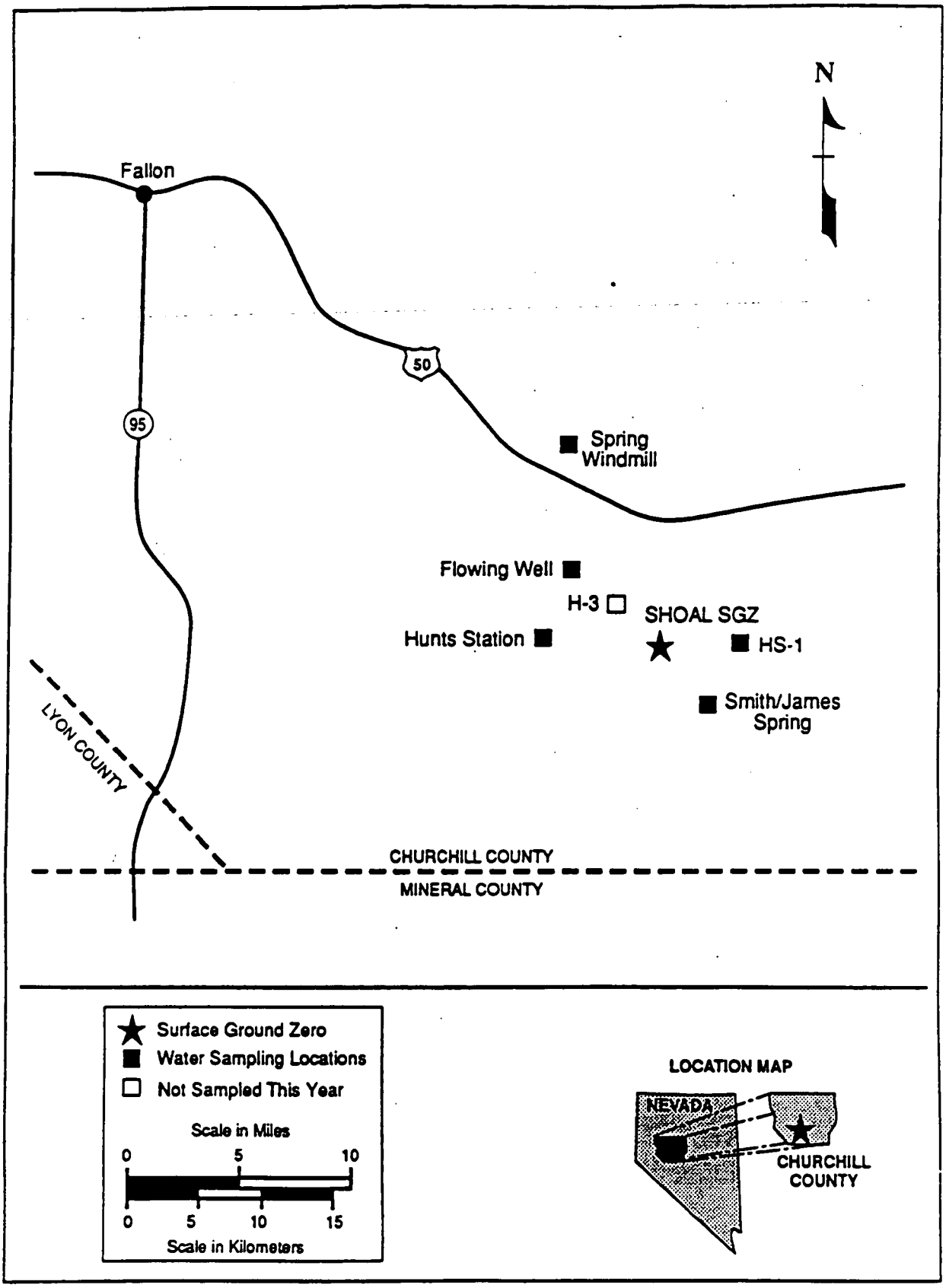

Figure 9.9 LTHMP Sampling Locations for Project SHOAL - 1991

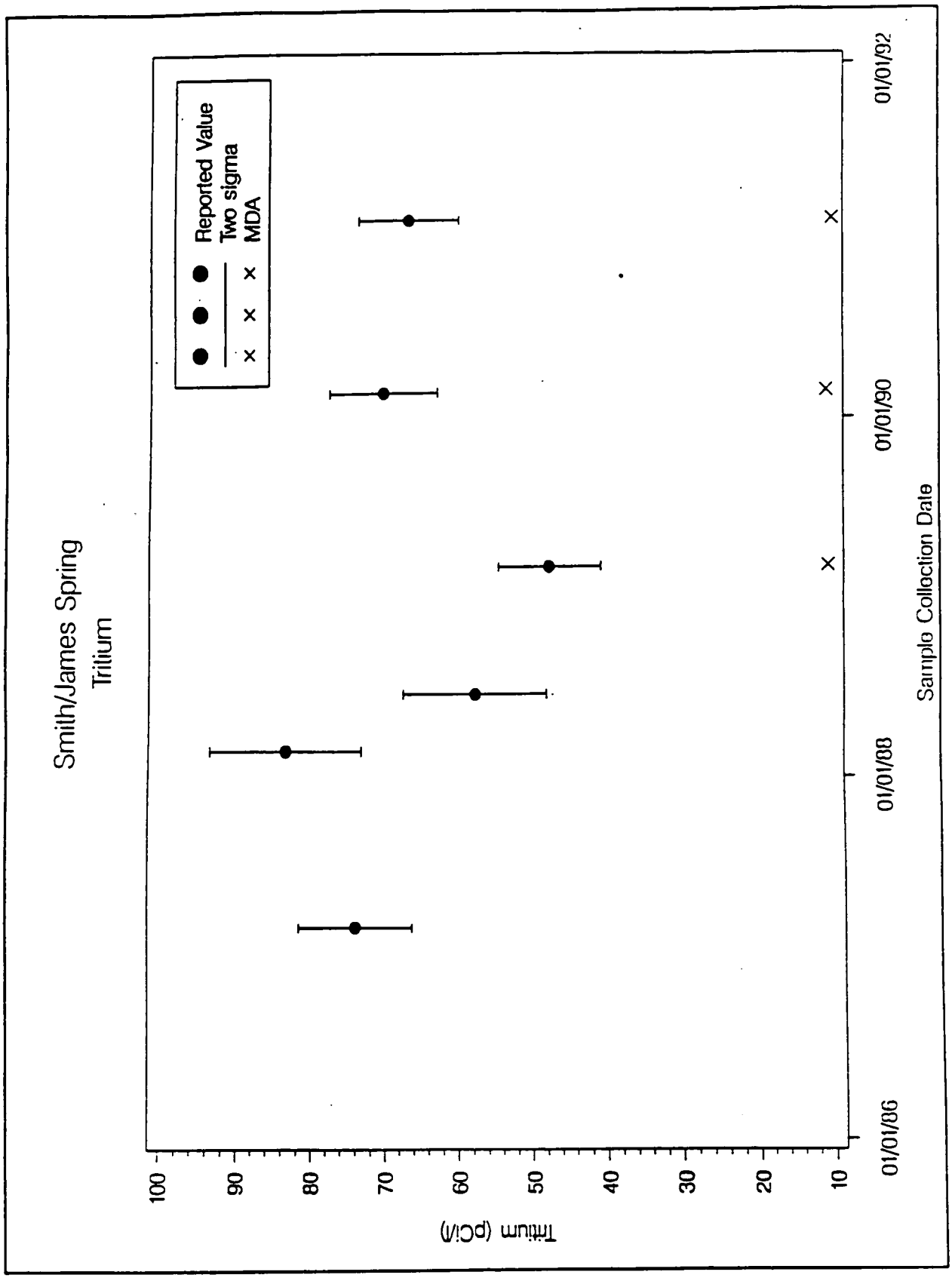

Figure 9.10 Tritium Results for Water from Smith/James Spring, Nevada

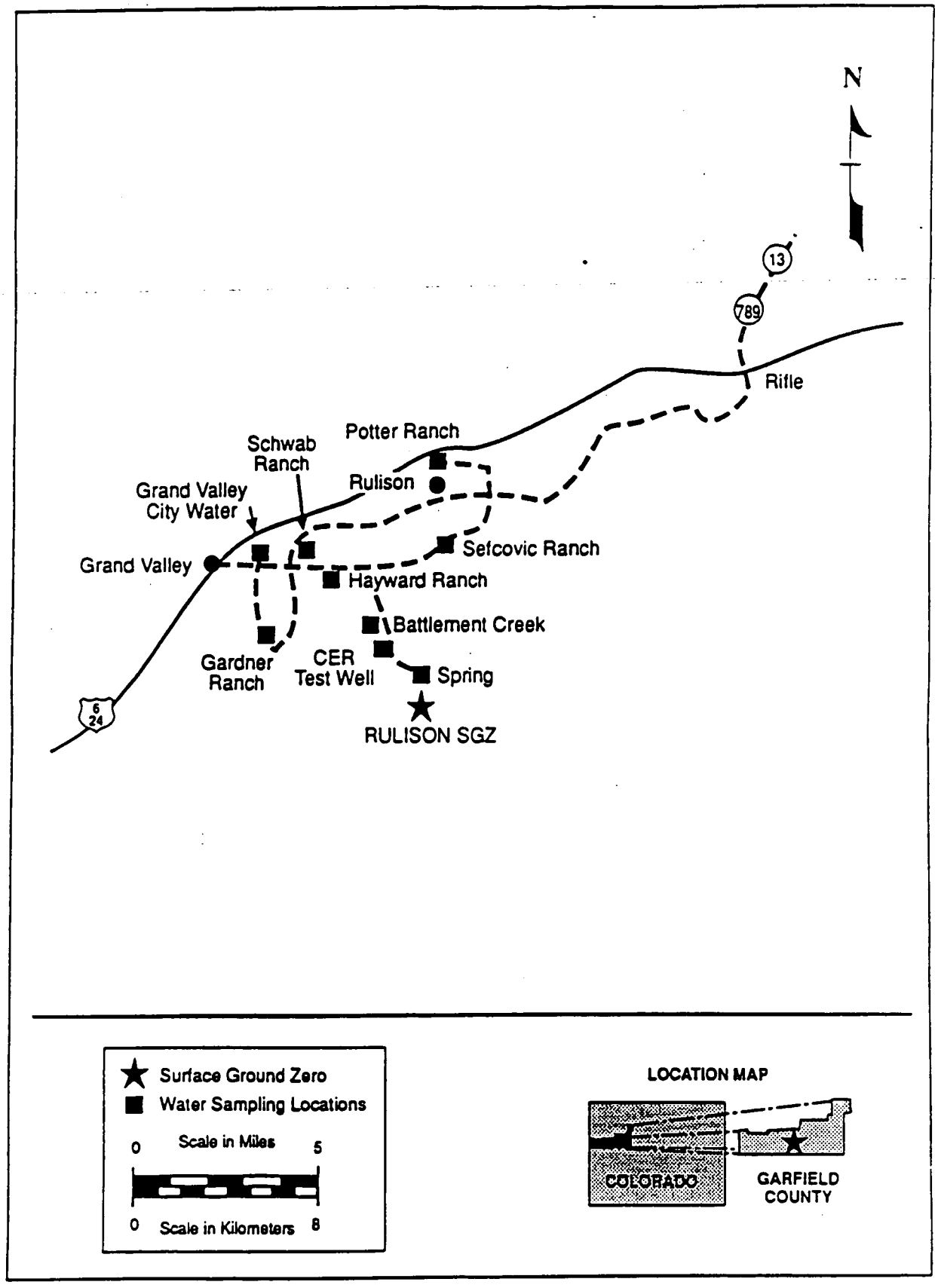

Figure 9.11 LTHMP Sampling Locations for Project RULISON - 1991

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exhibited a decreasing trend over the last two decades. The range of tritium activity in the 1991 samples was from 56 ± 3 pCi/L at Battlement Creek to 187 ± 4 pCi/L at Lee Hayward Ranch (see Table D.9, Appendix D). These values are 0.06 to 0.21% of the National Primary Drinking Water Regulation using DCGs from ICRP-30. The detectable tritium activities are probably a result of the natural high background in the area. This is supported by the DRI analysis, which indicated that most of the sampling locations are shallow, drawing water from the surficial aquifer which is unlikely to become contaminated by any radionuclides arising from the Project RULISON cavity (Chapman and Hokett, 1991). Figure 9.12 displays data for the last 20 years for Lee Hayward Ranch. The low value obtained in 1990 was attributed to analytical bias and was observed consistently for all Project RULISON sampling locations.

9.6.4 PROJECT RIO BLANCO

Like Project RULISON, Project RIO BLANCO was a joint government-industry test designed to stimulate natural gas flow and was conducted under the Plowshare Program. The test was conducted on May 17, 1973, at a location between Rifle and Meeker, Colorado. Three explosives with a total yield of 90 kt were emplaced at 1780, 1920 and 2040 m (5838, 6229, and 6689 ft) depths in the Ft. Union and Mesa Verde formations. Production testing continued to 1976; tritiated water produced during testing was injected to 1710 m (5600 ft) in a nearby gas well. Cleanup and restoration activities were completed by November 1976.

Samples were collected on June 12 and 13, 1991. One routine sampling location, Brennan Windmill, was not sampled because the windmill was inoperative. The sampling sites, shown in Figure 9.13, include two shallow domestic water supply wells, six surface water sites along Fawn Creek, three springs, and three monitoring wells located near the cavity. At least two of the monitoring wells (wells RB-D-01 and RB-D-03) are suitable for monitoring possible cavity migration. All of the springs had tritium activities of approximately 60 pCi/L (range 60 to 62 pCi/L). These values are <0.1 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30 (see Table D.10, Appendix D). Of two shallow domestic wells located near the Project RIO BLANCO site, one could not be sampled in 1991 and the other yielded no detectable tritium activity. All of the sampling sites along Fawn Creek yielded tritium activities of approximately 30 pCi/L (range 27 to 34 pCi/L), less than 0.04 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30. There is no statistically significant difference observed between sites located upstream and downstream of the cavity area. Tritium data for two Fawn Creek Stations are shown in Figure 9.14. The three monitoring wells all yielded no detectable tritium activity, indicating that migration from the test cavity has not occurred.

9.6.5 PROJECT GNOME

Project GNOME, conducted on December 10, 1961, near Carlsbad, New Mexico, was a multipurpose nuclear test performed in a salt formation. A slightly more than 3-kt nuclear explosive was emplaced at 371 m (1216 ft) depth in the Salado salt formation. Radioactive gases were unexpectedly vented during the test. The U.S. Geological Survey (USGS) conducted a tracer study in 1963, involving injection of 20 Ci tritium, 10 Ci ^{137}Cs, 10 Ci ^{90}Sr, and 4 Ci ^{131}I; wells USGS 4 and 8 were used for this tracer study. During remediation activities in 1968-69, contaminated material was placed in the test cavity up to within seven ft of the surface. More material was slurried into the cavity and drifts in 1979.Sampling in the area of Project GNOME was completed between June 22 and 25, 1991. A total of 11 samples were collected from routine sampling locations in Carlsbad, Loving, and Malaga, New

Mexico. One location, Well 1 at the Pecos Pumping Station, was not sampled because access could not be obtained. The routine sampling sites, depicted in Figure 9.15, include nine monitoring wells in the vicinity of surface GZ, the municipal supplies at Loving and Carlsbad, New Mexico, and the Pecos River Pumping Station well. As in previous years, the municipal water supplies indicated no detectable tritium activity. An analysis by DRI (Chapman and Hokett, 1991) indicates the Loving and Carlsbad municipal supply wells, located on the opposite side of the Pecos River from the Project GNOME site, are not connected hydrologically to the site and, therefore, cannot become contaminated by Project GNOME radionuclides.

Tritium results greater than the MDC were detected in water samples from six of the nine sampling locations in the immediate vicinity of GZ. In addition to tritium, detectable activity concentrations of ^{137}Cs and ^{90}Sr were observed in Well DD-1, which samples water in the test cavity, Well LRL-7 which samples a sidedrift, and wells USGS 4 and 8, which were used in the radionuclide tracer study conducted by USGS. The remaining two wells with detectable tritium concentrations were PHS wells 6 and 8, with results of 41 ± 3 pCi/L and 13 ± 3 pCi/L, respectively (see Table D.11, Appendix D). These values are 0.05 and less than 0.02 percent, respectively, of the National Primary Drinking Water Standard using DCGs from ICRP-30. In all cases, the tritium activities exhibit a decreasing trend, as depicted in Figure 9.16. No tritium was detected in the remaining Project GNOME samples, including USGS Well 1, which the DRI analysis (Chapman and Hokett, 1991) indicated is positioned to possibly detect cavity migration, should it occur.

9.6.6 PROJECT GASBUGGY

Project GASBUGGY, similar to Project RULISON was a Plowshare Program test cosponsored by the U.S. government and El Paso Natural Gas. Conducted near Gobernador, New Mexico on December 10, 1967, the test was designed to stimulate a low productivity natural gas reservoir. A nuclear explosive with a 29-kt yield was emplaced at a depth of 1290 m (4240 ft). Production testing was completed in 1976 and restoration activities were completed in July 1978.

Thirteen samples were collected between June 17 to 19, 1991. Well 30.3.32.343 (North) has been removed and, therefore, has been deleted from the routine sampling directory. A sample was collected from the Old School House Well at the request of the State of New Mexico. This was intended to be a one-time sample only, but the site is being considered for addition to the routine sampling directory due to its location in the probable downgradient direction from the test cavity. The routine sampling locations include seven wells, one windmill, three springs, and two surface water sites, depicted in Figure 9.17. The two surface water sampling sites yielded tritium activities of 40 ± 2 pCi/L and 46 ± 2 pCi/L. The three springs yielded tritium activities that were not much higher, ranging from 48 ± 3 pCi/L to 71 ± 3 pCi/L, all about 0.05% of the National Primary Drinking Water Regulation using DCGs from ICRP-30. Tritium activities in shallow wells varied from less than the MDC to 50 ± 2 pCi/L, which are less than 0.01 to 0.03 percent of the National Primary Drinking Water Standard (see Table D.12, Appendix D).

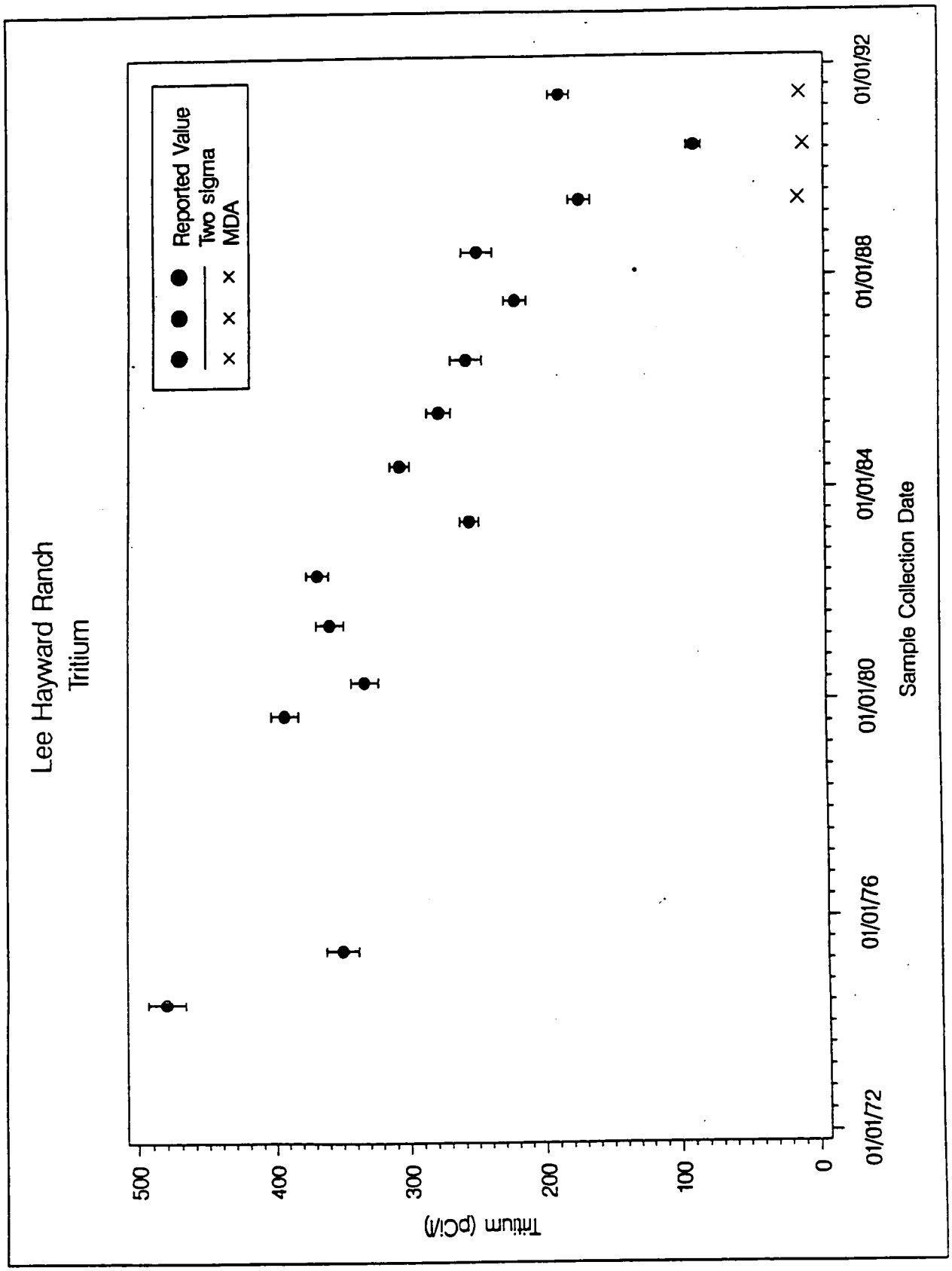

Figure 9.12 Tritium Trends in Groundwater, Hayward Ranch, Colorado

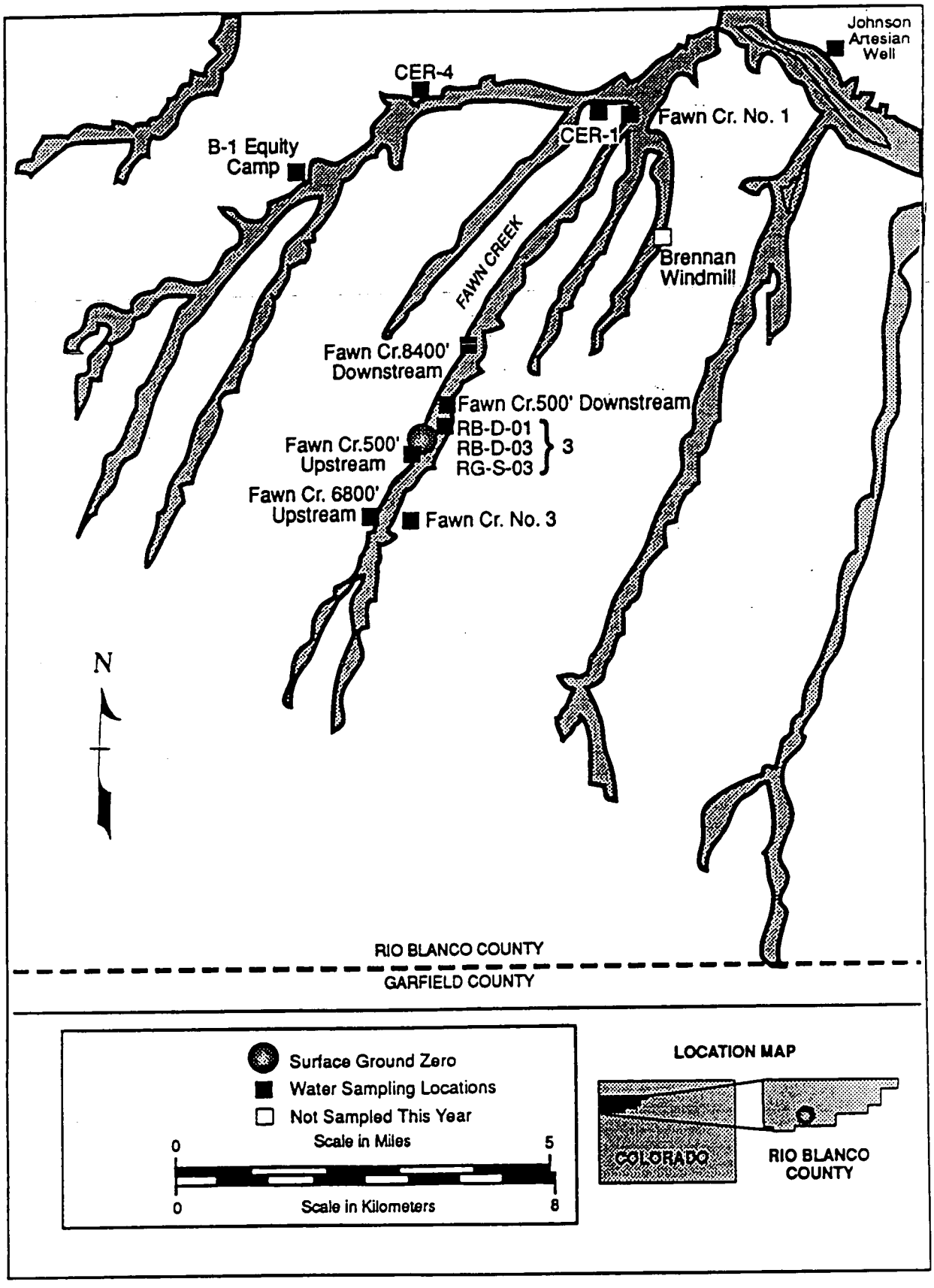

Figure 9.13 LTHMP Sampling Locations for Project RIO BLANCO, Colorado

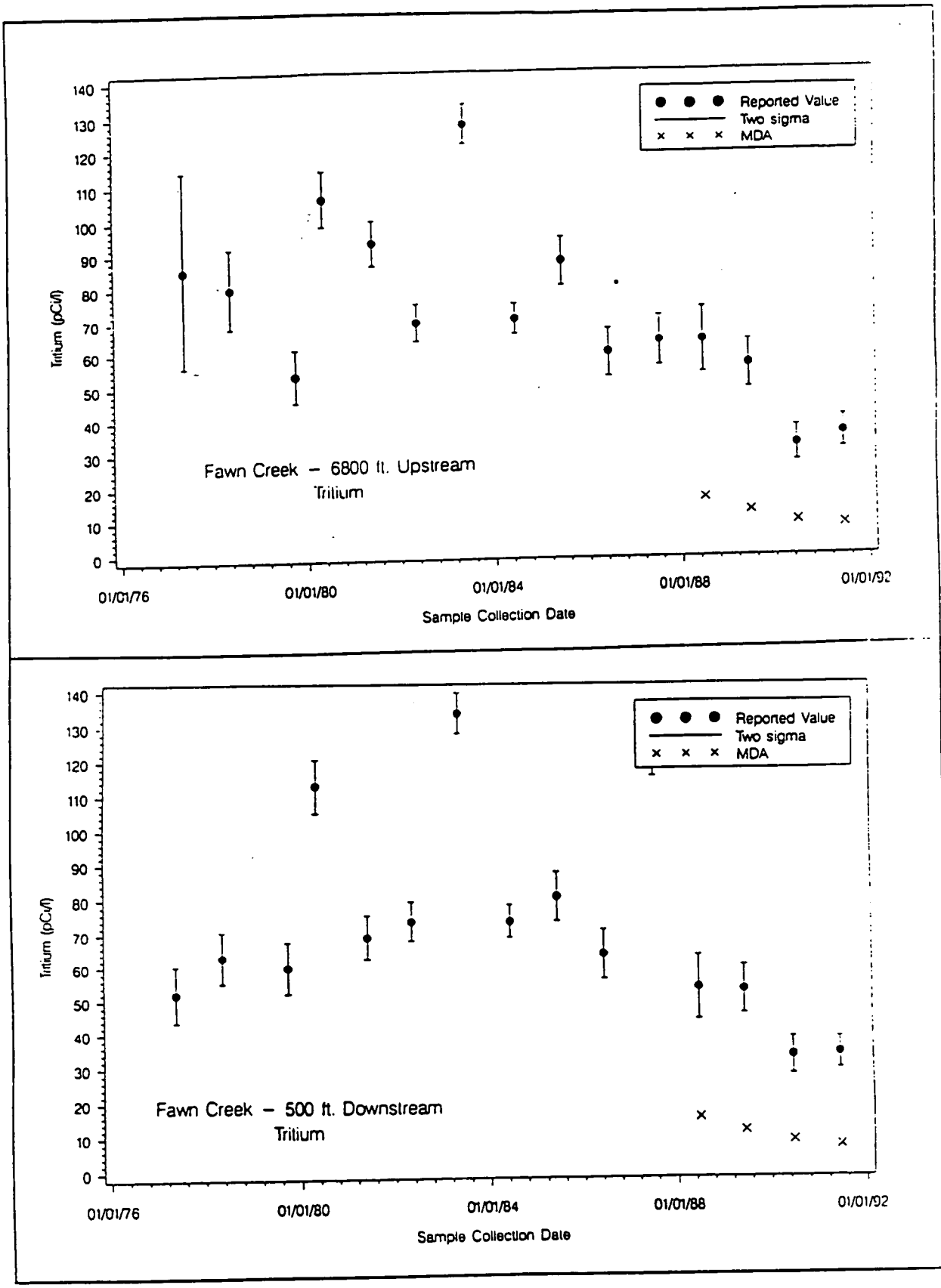

Figure 9.14 Tritium Results in Water Samples from Fawn Creek, Colorado

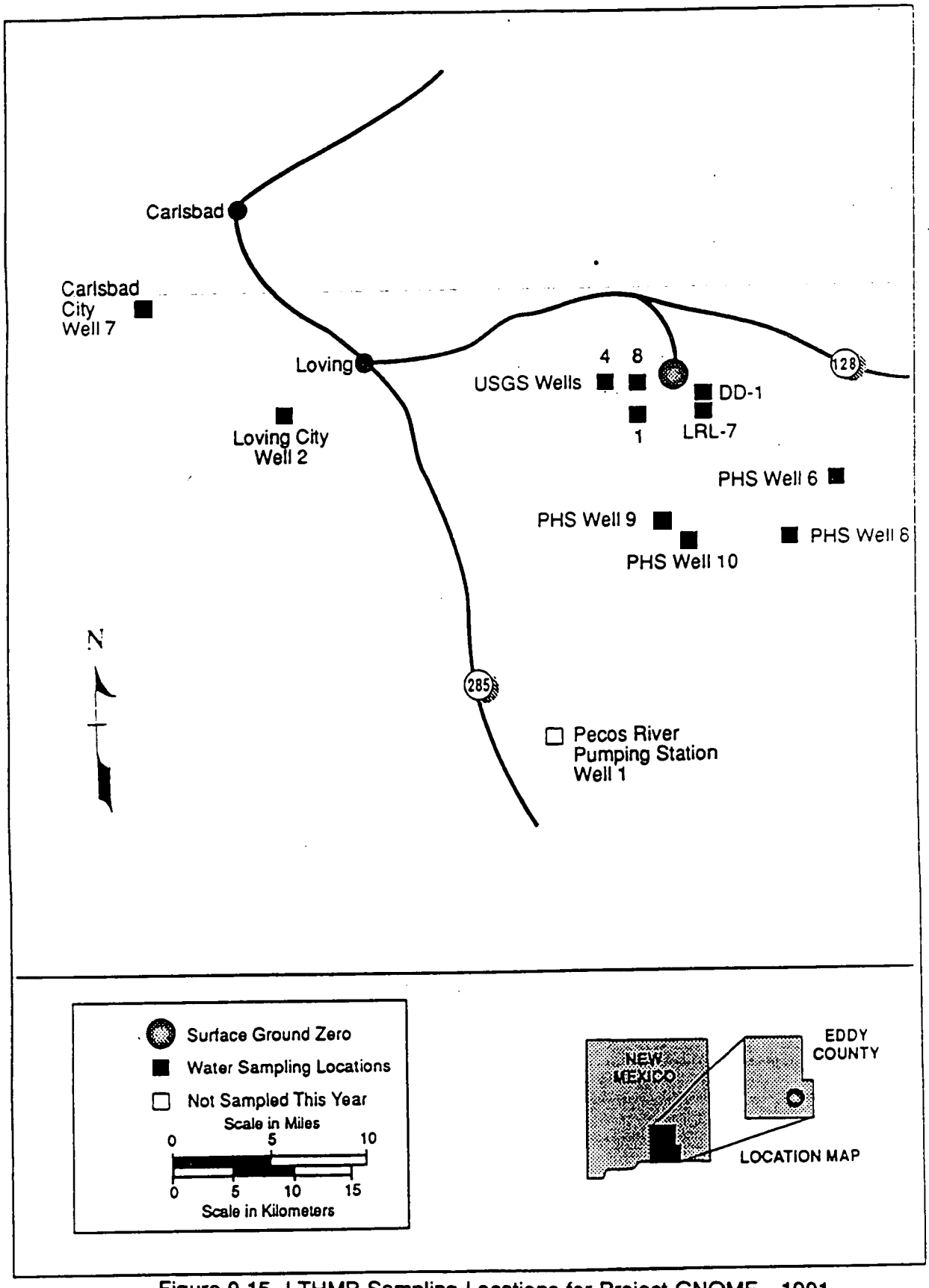

Figure 9.15 LTHMP Sampling Locations for Project GNOME - 1991

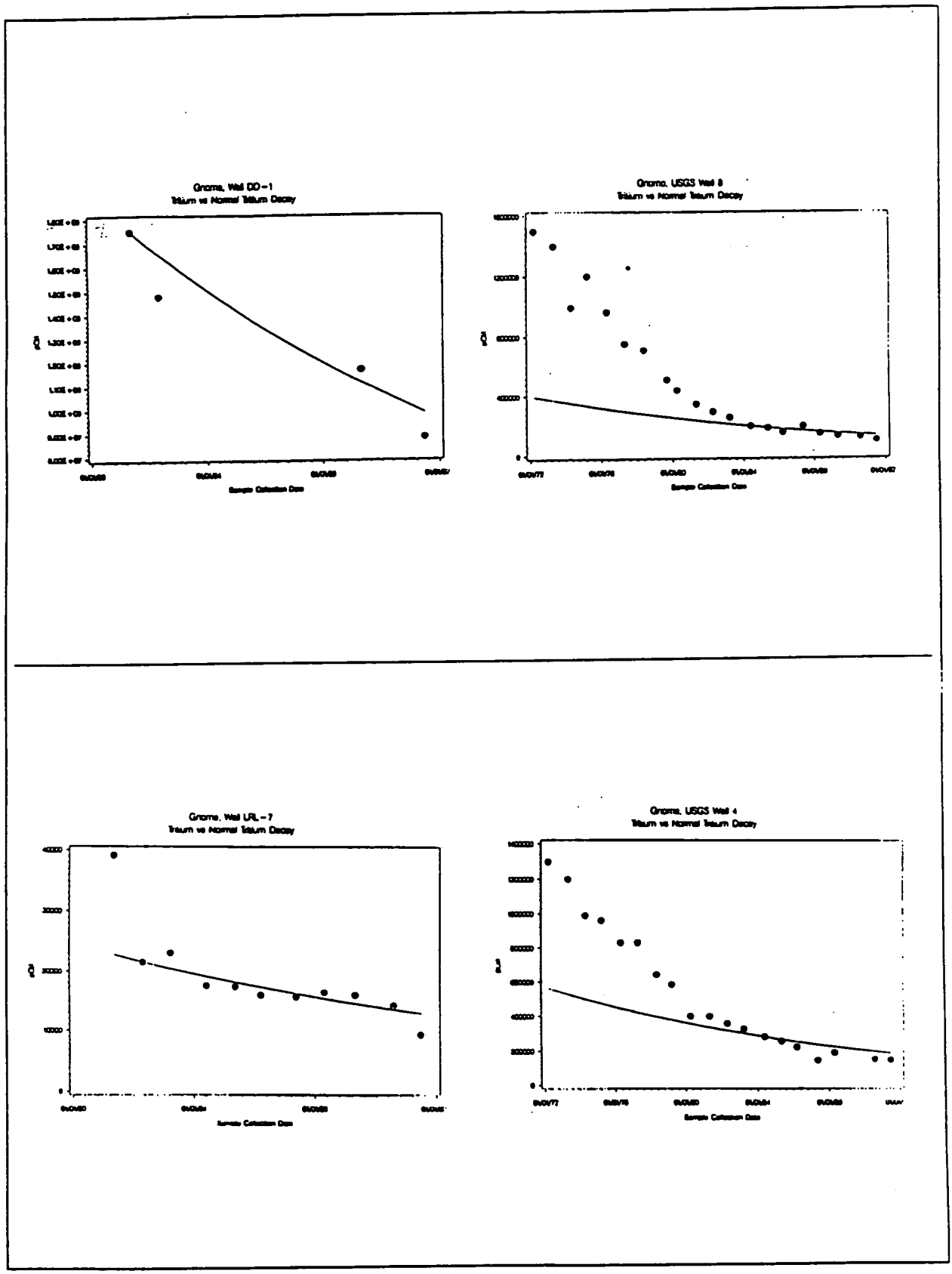

Figure 9.16 Tritium Results in Water from Project GNOME Wells

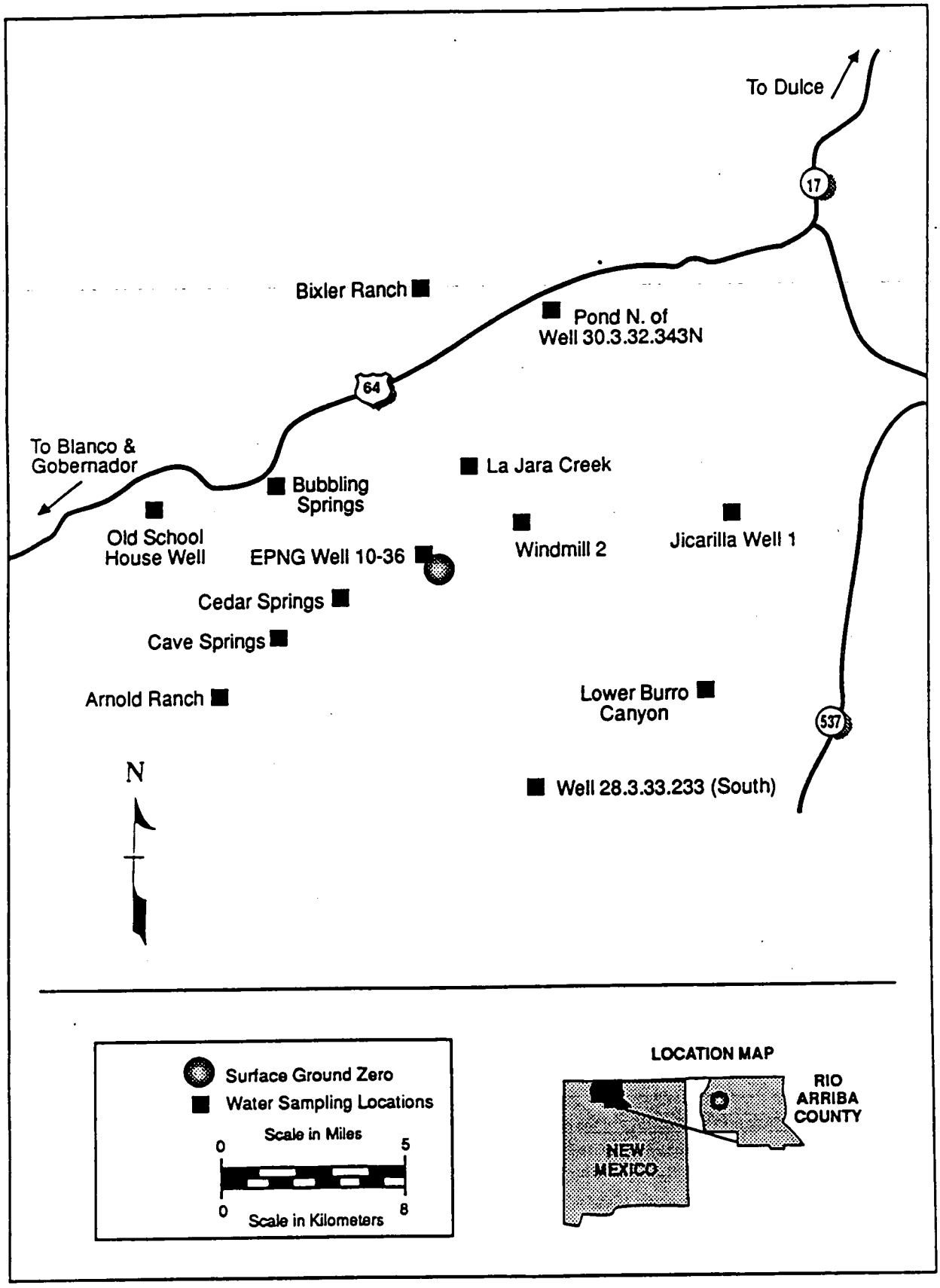

Figure 9.17 LTHMP Sampling Locations for Project GASBUGGY - 1991

Well EPNG 10-36, a gas well located 132 m (435 ft) northwest of the test cavity with a sampling depth of approximately 1100 m (3600 ft), yielded a tritium activity of 484 ± 4 pCi/L in 1991. Prior to 1984, all tritium activities measured in this well were less than 45 pCi/L, a value which may be considered the background activity for this location. In 1984 and every year since then, with the exception of 1987, tritium activities have been between 100 and 560 pCi/L, with occasionally wide variability noted between consecutive years. In each of the last three years, the activity in this well has approximately doubled, as shown in Figure 9.18. The proximity of the well to the test cavity suggests the possibility that the increased activity may be indicative of migration from the test cavity. Representatives of DOE, DRI, and EPA are currently working on a sampling plan for this well to further investigate the increased activity.

9.6.7 PROJECT DRIBBLE

Project DRIBBLE was comprised of four explosive tests, two nuclear and two gas, conducted in the Tatum Salt Dome area of Mississippi under the Vela Uniform Program. The purpose of Project DRIBBLE was to study the effects of decoupling on seismic signals produced by explosives tests. The first test, SALMON, was a nuclear device with a yield of about 5 kt, detonated on October 22, 1964, at a depth of 826 m (2710 ft). This test created the cavity used for the subsequent tests, including STERLING, a nuclear test conducted on December 3, 1966, with a yield of about 380 tons, and the two gas explosions, DIODE TUBE, conducted on February 2, 1969, and HUMID WATER, conducted on April 19, 1970. The ground surface and shallow groundwater aquifers were contaminated by disposal of drilling muds and fluids in surface pits. The radioactive contamination was primarily limited to the unsaturated zone and upper, nonpotable aquifers. Shallow wells, labeled HMH wells on Figure 9.19 have been added to the area near surface GZ to monitor this contamination. In addition to the monitoring wells surrounding GZ, extensive sampling is conducted in the nearby offsite area. Most private drinking water supply wells are included, as shown in Figure 9.20.

Sampling on and in the vicinity of the Tatum Salt Dome was conducted between April 21 and 24, 1991. A total of 104 samples were collected; eight of these were from new sampling locations in Columbia and Lumberton, Mississippi. Eight routine sampling locations were not sampled. In two cases, the residents (Rita Smith and Donald Beach) have moved and the well is not in operation. These sampling locations will not be sampled again unless new residents reopen the well. Another resident (M. Lowe) switched to rural water and is no longer using a well, thus eliminating the need to sample at this location. The other five samples not taken this year were unobtainable due to inaccessibility of the sampling location because of local flooding or because the resident was not home.

In the 47 samples collected from offsite sampling locations, tritium activities ranged from less than the MDC to 48 ± 4 pCi/L, equivalent to less than 0.01 to 0.06 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30. The results do not exceed the natural tritium activity expected in rainwater in the area. Uranium-238 was detected at concentrations greater than the MDC in three of the water samples collected from the eight new sampling locations and ^{234}U was greater than the MDC in one sample. The highest ^{238}U was 0.0705 ± 0.0191 pCi/L and the highest ^{234}U was 0.0537 ± 0.0163 pCi/L, both in the water sample collected from the pond on the Howard Smith property in Lumberton, Mississippi. These activities are extremely low and probably of natural origin.

Due to the high rainfall in the area, the normal sampling procedure is modified for the shallow onsite wells. Following collection of a first sample, the well is pumped for a set period

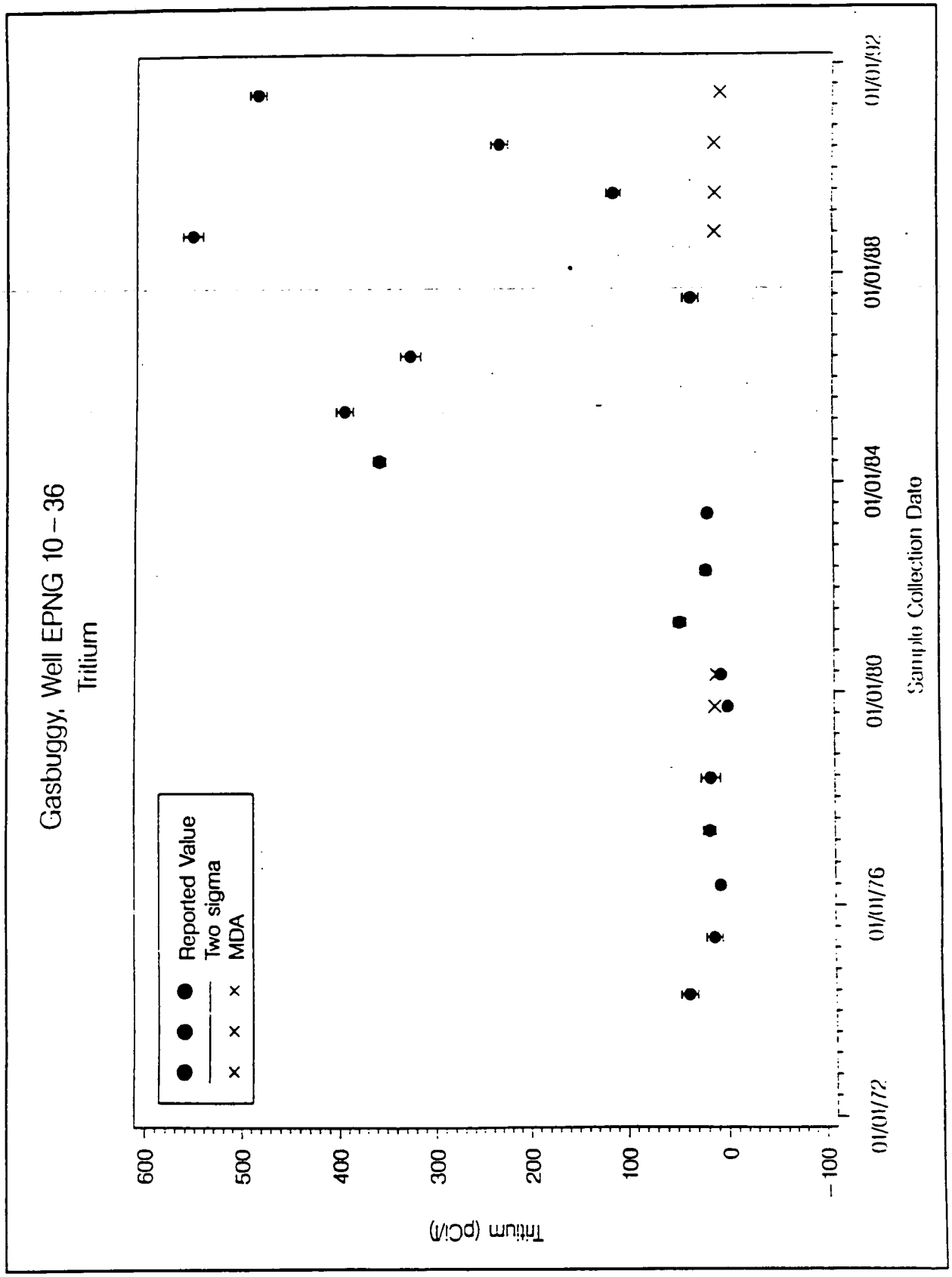

Figure 9.18 Tritium Trend in Groundwater, Well EPNG 10-36, GASBUGGY

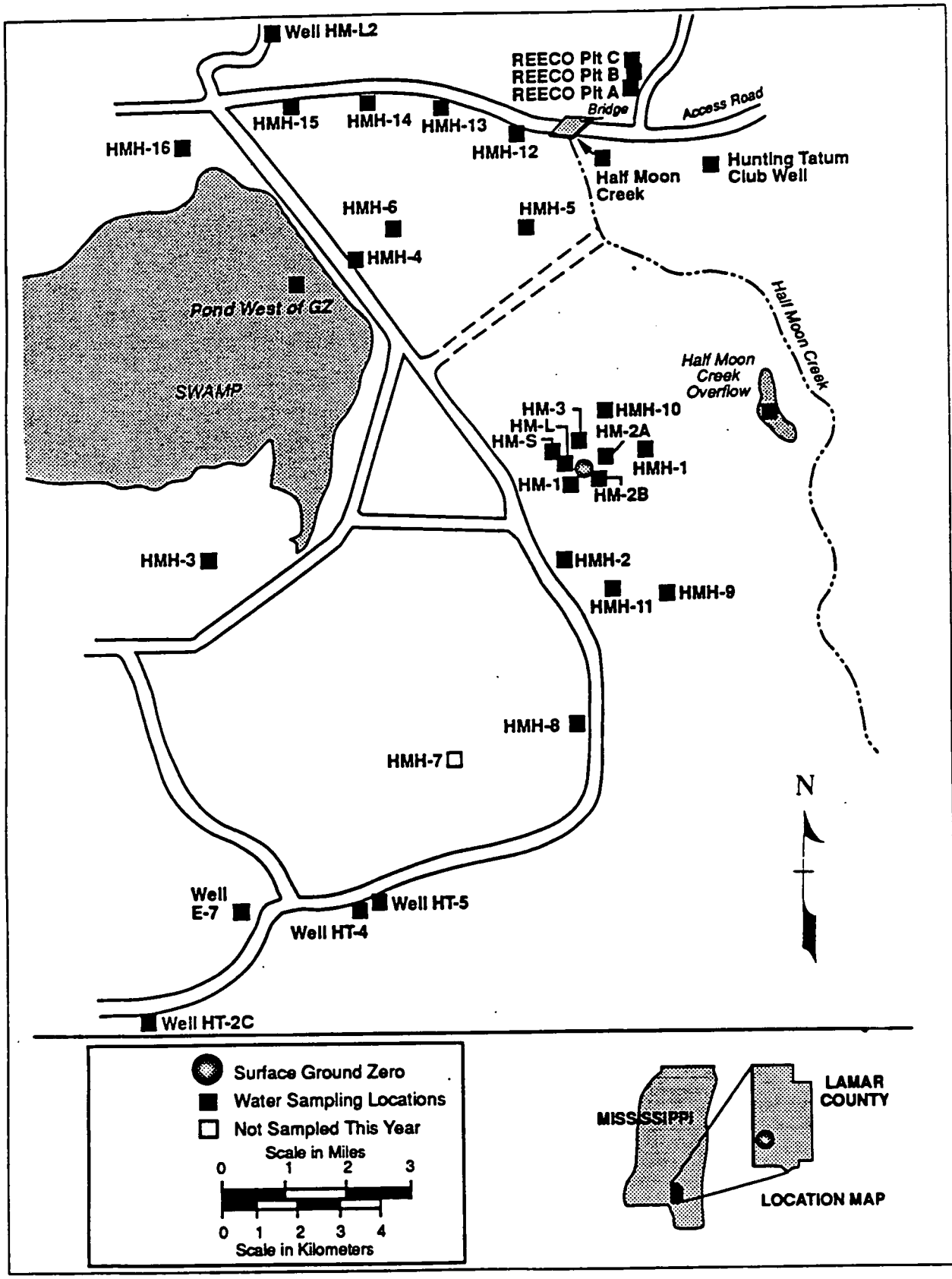

Figure 9.19 LTHMP Sampling Locations for Project DRIBBLE, Near Ground Zero - 1991

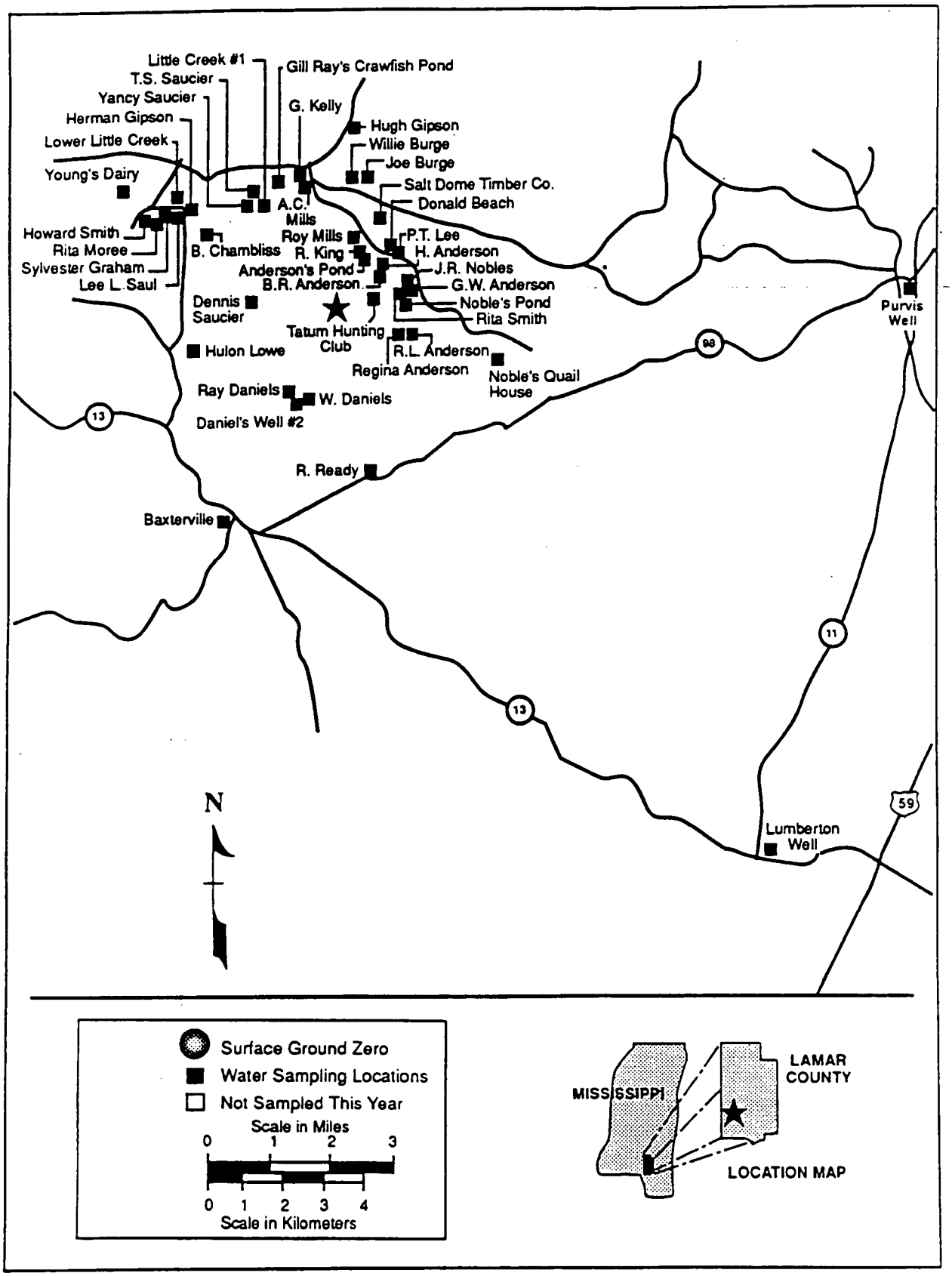

Figure 9.20 LTHMP Sampling Locations for Project DRIBBLE, Town and Residences - 1991

of time or permitted to refill and a second sample is collected. The second samples are thought to be more representative of the formation water. Thirty-two locations were sampled in the vicinity of GZ; 23 of these yielded tritium activities greater than the MDC in either the first or second sample. Overall, tritium activities ranged from less than the MDC to 1.44×10^4 ± 200 pCi/L as shown in Table D.13, Appendix D. The locations where the highest tritium activities were measured generally correspond to areas of known contamination. None of the samples indicate any migration of radionuclides from the test cavity. Results of sampling related to Project DRIBBLE are discussed in greater detail in *Onsite and Offsite Environmental Monitoring Report: Radiation Monitoring around Tatum Salt Dome, Lamar County, Mississippi, April 1991* (Thomé et al, in press).

9.6.8 AMCHITKA ISLAND, ALASKA

Three nuclear weapons tests were conducted on Amchitka Island in the Aleutian Island chain of Alaska. Project LONG SHOT, conducted on October 29, 1965, was an 85-kt yield test under the Vela Uniform Program, designed to investigate seismic phenomena. Project MILROW, conducted on October 2, 1969, was an approximately 1-Mt "calibration test" of the seismic and environmental response to the detonation of large-yield nuclear explosives. Project CANNIKIN, conducted on November 6, 1971, was a proof test of the Spartan antiballistic missile warhead with a less than 5-Mt yield. Project LONG SHOT resulted in some surface contamination, even though the chimney did not extend to the surface.

Sampling on Amchitka Island, Alaska, was conducted between September 21 and 24, 1991. Four locations were sampled for the first time. These four new sampling sites are Constantine Spring Pump House, RX-Site Pump House, TX-Site Springs, and TX-Site Water Tank (House). Of the routine sampling locations, nine were not sampled. Army Well 3 and the Site D Hydrological Exploratory Hole are plugged and, therefore, are being eliminated from the routine sampling directory. The Site E Hydrological Exploratory Hole was not sampled due to the presence of oil in the hole. Five EPA wells were not sampled because the wells were in the lake (flooded); these were EPA wells 9, 12, 16, 17, and 19. Another well, EPA 4, was dry. In addition, two sampling locations were deleted from the routine sampling directory prior to the initiation of sampling. These were the Decon Pump and Decon Sump which were eliminated because past data indicates no potential for detection of radioactive contaminants. Locations for background sampling are shown in Figure 9.21, for Projects LONG SHOT and MILROW in Figure 9.22, and for Project CANNIKIN in Figure 9.23.

It is likely that any migration from the test cavities would discharge to the nearest salt water body, Project MILROW to the Pacific Ocean and Projects LONG SHOT and CANNIKIN to the Bering Sea (Chapman and Hokett, 1991). The sampling locations on Amchitka Island are shallow wells and surface sampling sites. Therefore, the monitoring network for Amchitka Island is restricted to monitoring of surface contamination and drinking water supplies.

Sample results are consistent with the sampling history for the area. Samples collected from the four new sampling locations yielded gross alpha and gross beta results greater than the MDC for those scans. The highest values were 2.9 ± 0.7 pCi/L gross alpha and 7.3 ± 0.8 gross beta for the Constantine Spring Pump House. In general, while most samples contain tritium concentrations detectable by the enrichment method of analysis (minimum detectable activity approximately 7 to 10 pCi/L), the levels are extremely low and continue to evidence the decreasing trend observed throughout the sampling history. With the exception of five of the Project LONG SHOT sampling locations, all tritium results were less than 50 pCi/L.

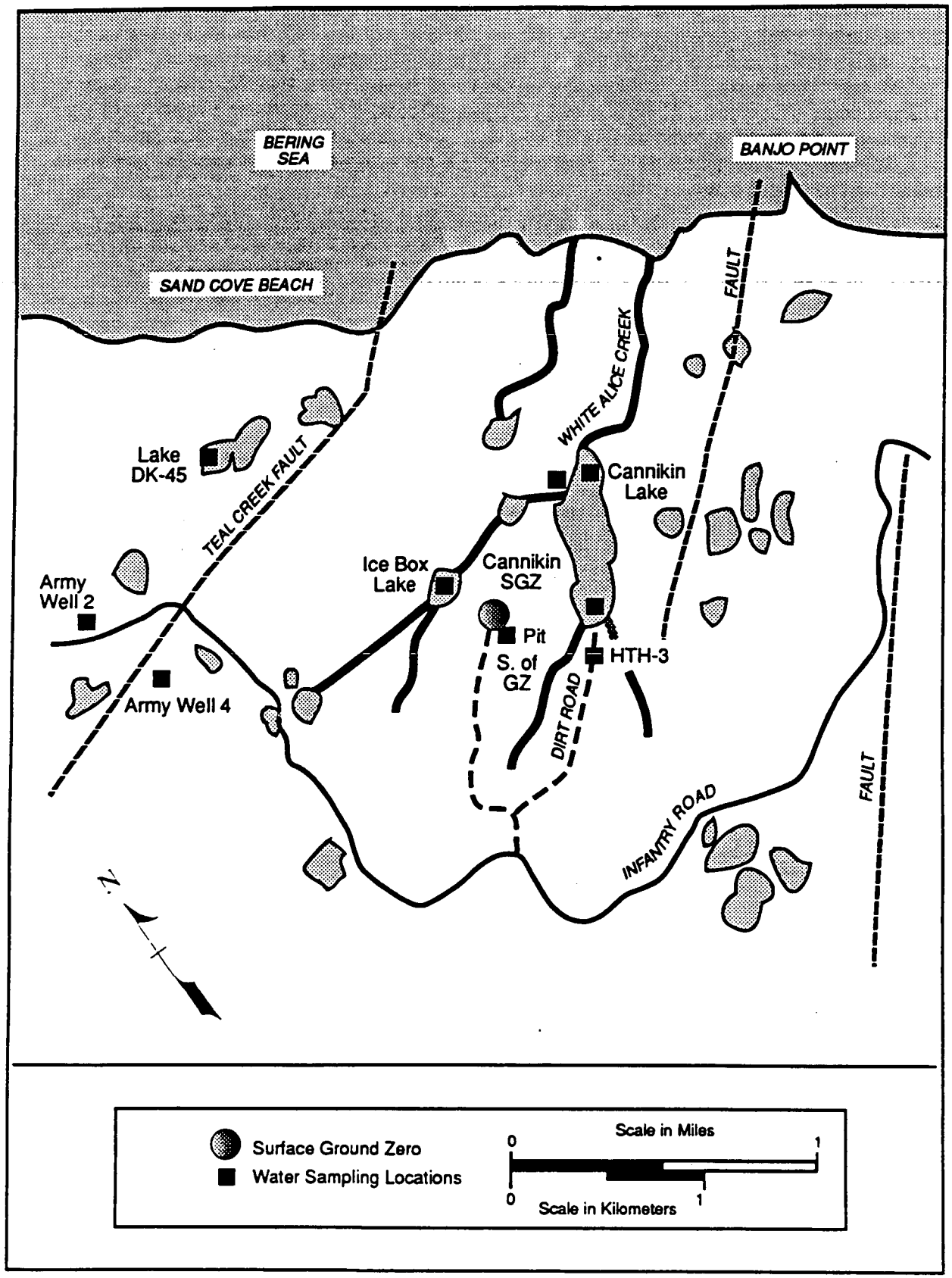

Figure 9.23 Sampling Locations for Project CANNIKIN

Samples from the three Mud Pits and the stream east of LONG SHOT yielded tritium activities of approximately 225 pCi/L (range 190 ± 3 pCi/L to 282 ± 3 pCi/L). Of these, only the stream east of LONG SHOT has the potential to be used as drinking water. The measured ^{3}H activity for this site was 190 ± 3 pCi/L, which is 0.21 percent of the National Primary Drinking Water Regulation using DCGs from ICRP-30. Well GZ No. 1, located in or near the Project LONG SHOT cavity, had a tritium activity of 1130 ± 99 pCi/L. All of these sampling locations have shown a decreasing trend over time. The analytical results for all of these samples are shown in Table D.14, Appendix D.

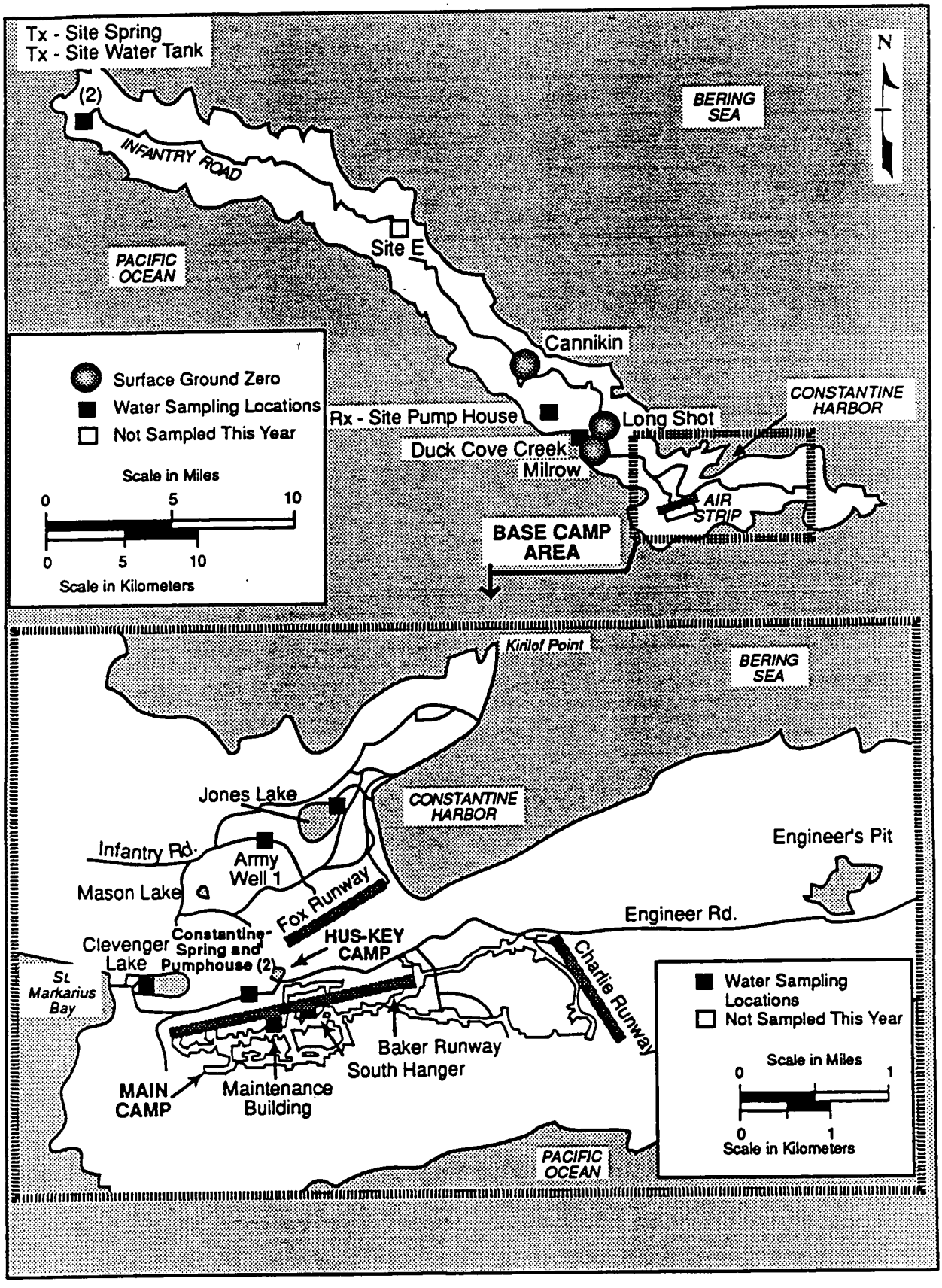

Figure 9.21 Amchitka, Alaska, Background Sampling Locations

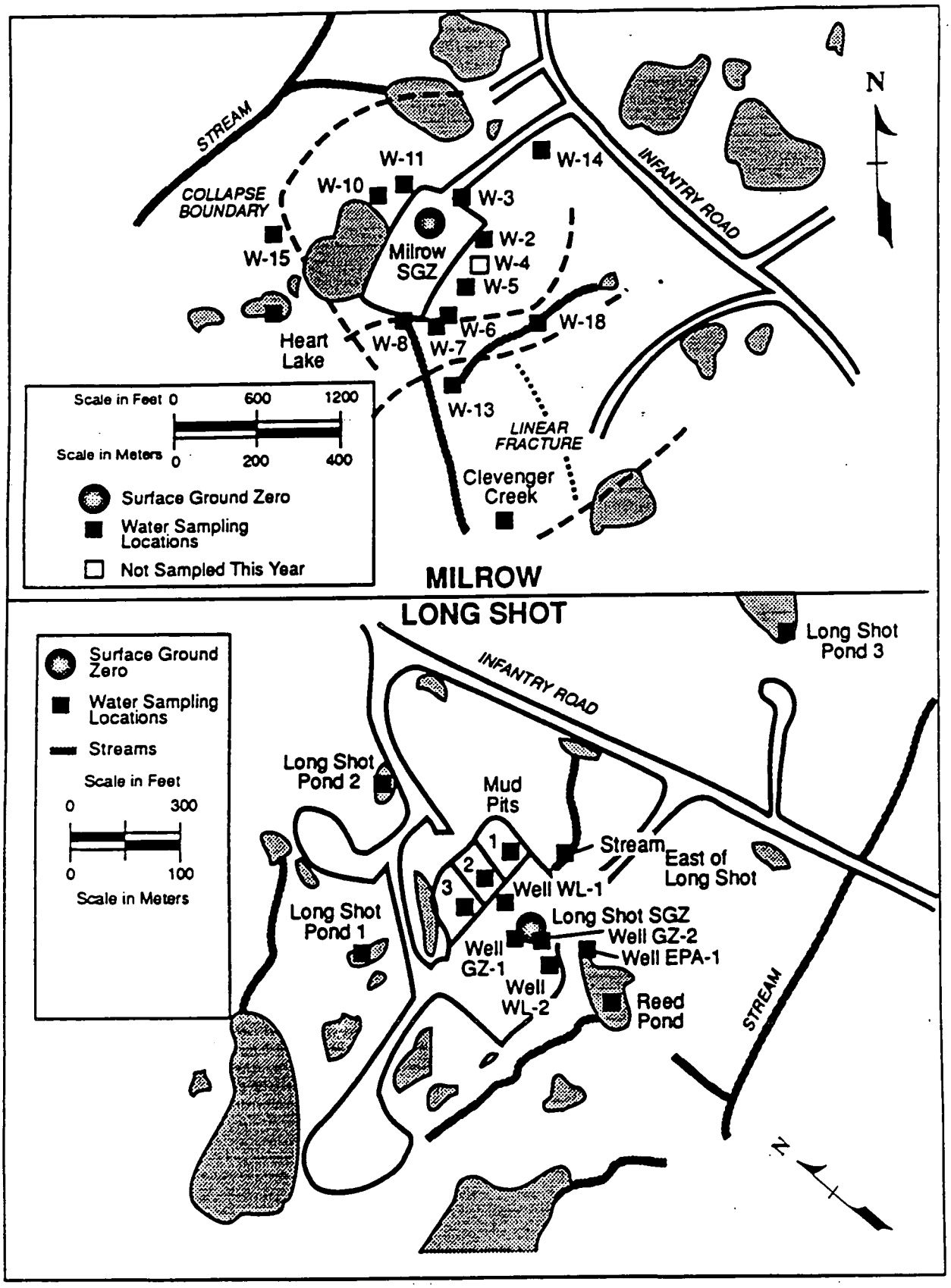

Figure 9.22 Sampling Locations for Projects MILROW and LONG SHOT

10.0 ONSITE RADIOLOGICAL QUALITY ASSURANCE

Yun Ko Lee and Kevin R. Krenzien

The radiological quality assurance (QA) program includes conformance to best laboratory practice. The external quality assurance intercomparison program for radiological data quality assurance consists of participation in the DOE Quality Assessment Program (QAP) administered by the DOE Environmental Measurements Laboratory (EML); the Nuclear Radiation Assessment and Cross Check Program (NRACC) conducted by the EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV); and the quality assessment program sponsored by the International Reference Center for Radioactivity (IRCR) of the World Health Organization (WHO).

10.1 OVERVIEW OF THE ONSITE QUALITY ASSURANCE PROGRAM

The 1991 QA program for onsite radiological environmental monitoring covered airborne effluents, liquid effluents, air, particulates, surface water, groundwater, and thermoluminescent dosimeter (TLD) ambient gamma monitoring for radioactive materials. Radiological sample collection, radiochemical analyses, and radiological monitoring of NTS samples were performed by the onsite operations contractor, Reynolds Electrical & Engineering Co., Inc. (REECo). The onsite contractor laboratory maintained both internal and external quality control (QC) programs to ensure that the data and analytical results obtained were representative of the actual concentrations in the environment and were of known quality.

Large numbers of routinely scheduled environmental samples were collected at various locations on the NTS in support of the nuclear testing programs and the Radioactive Waste Management Project. Samples from all locations were collected using documented REECo Health Protection Department (HPD) standard operating procedures. Current data for each environmental medium were compared to both recent results and historical data for each location to ensure that any deviations from previous conditions were identified and promptly evaluated. Review of analytical results relative to the applicable DOE orders and standards was performed on a daily basis to ensure that potential problems were noted in a timely manner.

A QA/QC program for radiological monitoring was maintained to ensure that the monitoring data generated could be used to accurately evaluate the environmental impacts from NTS operations. The continuous QA program focused on the following practices:

- Personnel training and work assignment qualifications
- Sample acquisition documentation
- Sample chain-of-custody control

- Procedural compliance
- Yield determination of radiochemistry procedures
- Analytical QA including blanks, spikes, and blind replicates used as QC samples to verify the maintenance of procedural control
- Routine source and background count checks for control of counting system performance
- Use of standards traceable to the National Institute of Standards and Technology (NIST) and NIST reference materials for instrument calibration and QC samples
- Calibration of sampling, analytical, and counting instruments
- Preventive and corrective maintenance for all systems which are crucial to data quality
- QC data and QC charts review to assure control of methods and processes
- Review of analytical data before reporting
- External audits and surveillances
- Internal compliance surveillances
- Actively participating in the interlaboratory QA programs conducted by the DOE, EPA, and WHO

10.2 SAMPLE CONTROL

Environmental monitoring samples were collected throughout the NTS and analyzed according to documented HPD standard operating procedures. Each of the samples submitted for analysis was identified with a unique packet number and was accompanied with a Laboratory Service Request and Chain of Custody Form. Personnel receiving the sample examined it and verified the information furnished on the accompanying forms. The sample preparation technician readied the sample materials for analyses. All samples were logged in through the Laboratory Data Analysis System (LDAS) resident on the HPD Laboratory VAX computer. Samples requiring chemical processing were signed out by appropriate radiochemistry laboratory personnel. Samples ready to be counted were signed out by radioanalysis counting laboratory personnel. When analysis was completed, the sample was returned to the sample custodian. Completed samples were normally stored for at least two months before disposal. When any samples were transferred to another person, verification signatures were required by both the persons submitting and receiving the samples.

10.3 INSTRUMENT CONTROL

Sampling, measuring, and test equipment used in the performance of quantitative measurements for the purpose of data production were controlled and calibrated utilizing specific calibration requirements and procedures. All calibration standards possessed similar matrices and the same or closest possible similar geometry and as the samples to be

counted. The efficiencies of counting instruments were established using standards prepared from NIST reference materials or certified reference materials traceable to the NIST. When a gamma spectrometer was certified, control charts and a plot of efficiency versus energy were prepared to identify the statistical error in the calibration of individual radionuclides and to estimate the efficiency of detection of radionuclides for which standards were not available.

Gamma spectrometers were set to count check sources of known activities on a daily basis. The peaks' centroid energies were compared against the expected energies. Daily performance tests were performed with a NIST-traceable multiradionuclide Laboratory Control Standard (LCS) with known radioactivities. The activities of three isotopes (^{241}Am, ^{137}Cs, and ^{60}Co) were calculated using production-mode computer algorithms, then compared with previous values. Counter backgrounds were measured regularly. Counters were decontaminated if background measurement showed evidence of above-background radiation levels. Instrument performance check activities and pertinent data were recorded in the individual instrument logbooks.

Calibration Check Standards (CCSs) of known activities were used for instrument performance tests of alpha spectrometers. The sample holders and the circular disks in which these are imbedded were cleaned as necessary and prior to performing the instrument performance tests. The peak channel (the full width at half maximum) and the count rate for each peak were recorded in the individual instrument logbook and were compared with both previous values and established acceptance criteria. Weekly background checks were performed and documented.

Proportional counters were set to count background and (CCSs) of known activities on a daily basis. Data were recorded in the individual instrument logbooks for comparison to previously acquired values, and control charts were prepared for instrument performance monitoring. Sample holders of the counters were thoroughly cleaned on a regular basis.

Liquid scintillation counters were set to count background and standards of known activity along with each batch of ten or fewer samples analyzed. Data were recorded in the instrument logbooks. The instruments were under service and maintenance contracts with each instrument's manufacturer for calibration and maintenance.

For all counting instruments, performance test data were accumulated and presented to the laboratory radioanalysis supervisor to be permanently filed. If data obtained from background and/or source checks were considered outside the instrument control limits or showed any inconsistencies, the cause of the problem was investigated and corrective actions taken. If the problem was found to be originated by the counting instrument, the instrument was removed from service. Any nonconforming instrument was repaired and recertified before it was allowed back in service. Performance histories of the counting instruments were maintained in instrument logbooks.

10.4 RADIOANALYSIS CONTROL

Personnel handling sample collection, preparation, and analysis were trained, qualified, and certified for their work assignments by their supervisors. Standard analytical methods used in radiochemistry analyses were derived from procedures published by the Environmental Measurements Laboratory, U.S. Department of Energy, New York, New York, for analyses of radionuclides. Drinking water samples were analyzed using procedures derived from those of EPA. In radiochemistry procedures, NIST-traceable standards were used, whenever feasible,

as tracers to determine the chemical yield. The yield was compared to previously determined acceptable control limits to provide an immediate evaluation of the process. Spiked samples were prepared from NIST-traceable materials for various analyses. Blanks, spikes, and replicates were submitted as QC samples to be analyzed along with every lot of field samples so that accuracy and precision of the analysis could be determined. The ratio of the number of QC samples to that of field samples analyzed varied depending on the types of analysis. Specific QC procedures and requirements were established and documented for each analysis. The laboratory QC program mandated that at least ten percent of the samples in each sample lot analyzed should be QC samples. However, in real practice, the number of QC samples analyzed was usually greater than the ten percent minimum.

10.5 DATA CONTROL

An internal QA/QC program was implemented to control and document the accuracy and precision of data generated. Sample and counting data were entered (or acquired) and stored on an appropriate data base of the laboratory LDAS computer. Counting data were processed, and results were generated. Pertinent information on the samples and their analyses were recorded. Analytical results were reported with the uncertainty limits and a minimum detection limit. Radionuclide concentrations were reported as calculated even when they were less than the detection limits or were negative. Analytical results were subjected to screening and peer review for accuracy. Analytical results were reviewed by the laboratory radioanalysis supervisor before being distributed and/or reported. Results of QC samples were promptly checked against the corresponding known values and examined with standard statistical methods. Control charts were plotted with 2 standard deviation (2s) warning limits and 3s control limits. If any result was found to be outside the control limits, the QC check sample was recounted. If the QC sample still exceeded the limit, the root cause of the problem was determined and corrective actions taken. The entire sample lot was then reanalyzed.

Corrective actions included, but were not limited to; interview with the analysts; performing data evaluation software verification and validation; recalibration of instruments; replacement of equipment; recollection and/or reanalysis of samples; retraining of personnel in correct implementation of sample collection, preparation, and analysis; reassignment of personnel to improve the overlap between the operator skills and method requirements; and revision of procedures.

Results were transferred to the REECo ShareBase 8000 Computer System as part of the historical data base and held for archives. Safeguards over the computer facility were provided as outlined in DOE Orders 1360.2 and 1330.1(c) to assure quality through the protection of results, equipment, and software.

10.6 EXTERNAL QUALITY ASSURANCE ASSESSMENT PROGRAMS

In addition to implementing the internal QA/QC program, the radioanalytical laboratory continued to participate in interlaboratory comparison and quality assessment programs in 1991.

One of these programs was the QAP conducted by the DOE/EML. The second program was the NRACC conducted by the EMSL-LV. Under both programs, a variety of standardized

samples were sent to the participating laboratories at intervals throughout the year. Such standard samples consisted of various environmental media (e.g., water, air filters, soil, milk, foodstuffs, vegetation, and tissue ash) containing one or more radionuclides in known amounts. After the samples were analyzed by the laboratories, the results were forwarded to the program sponsor for comparison with the known values and with the results from other participating laboratories. Both the DOE/EML and EPA/EMSL-LV have established criteria for evaluating the accuracy and precision of results (Jarvis and Siu 1981, Sanderson and Scarpitta 1990, and Sanderson and Scarpitta 1991). These programs served as a regular means of evaluating the performance of the radioanalytical laboratories and provided indications where corrective actions were needed. During 1991 the laboratory also participated in the quality assessment program sponsored by the IRCR/WHO. Analytical results were sent to IRCR/WHO, but no information feedback was received from IRCR/WHO for evaluation. Summaries of the 1991 results of the interlaboratory comparison and quality assessment programs conducted by the EPA/EMSL-LV and DOE/EML are provided in Tables 10.1 and 10.2. As illustrated in Tables 10.1 and 10.2, REECo results were generally within the control limits determined by the program sponsors. Causes or results outside the control limits were investigated, and corrective actions taken to correct the problems and to prevent reoccurrence.

10.7 COMPLIANCE AUDITS AND SURVEILLANCE

The REECo onsite laboratory was periodically audited for compliance by various divisions and branches of the DOE/NV and REECo Quality System Division. During 1991 the HPD Laboratory Operations Section also conducted internal surveillances on the radiochemistry, radioanalysis, and environmental surveillance functions of the laboratory for QA practices. Recommendations and corrective actions from the audit and surveillance reports were implemented or are in the process of being implemented.

10.8 RECENT DEVELOPMENTS IN THE QA/QC PROGRAM

The reorganization of the REECo Health Physics Laboratory and Industrial Hygiene Laboratory into the Analytical Services Department (ASD) influenced programmatic changes in the QA activities of the ASD. The reorganization of the ASD included the creation of a central quality support group. The mission of the Analytical Services Department (ASD) Quality Support Group (QSG) is to support the analytical capabilities of the ASD by performing ASD surveillances and management assessments; documenting and coordinating ASD indoctrination and training; coordinating responses to external audits and surveillances; tracking action items within the ASD; preparing independent quality control samples; coordinating reviews and revisions to ASD Standard Operating Procedures (SOPs); controlling SOPs by document control activities; administering the ASD laboratory intercomparison QA performance evaluation program; performing vendor audits of laboratory subcontractors; and overseeing the ASD Chemical Hygiene and Radiation Safety program. These activities are planned and structured to meet the requirements of DOE Orders, the REECo Quality Assurance Program, and ASD Quality Procedures.

Table 10.1 Results of EPA/EMSL-LV Nuclear Radiation Assessment and Cross Checks - 1991

Analysis/ Date	Water Samples, pCi/L REECo[a]	EPA/EMSL-LV[b]	Control Limits[c]	Ratio of REECo/ EMSL-LV
Gross Alpha				
04/16/91	69.3 ± 10.8	54.0 ± 14.0	29.7 - 78.3	1.28
10/22/91	71.0 ± 1.0	82.0 ± 21.0	45.6 - 118.4	86.6
Gross Beta				
04/16/91	90.0 + 11.0	115.0 ± 17.0	85.5 - 144.5	0.78
10/22/91	47.3 ± 1.5[e]	65.0 ± 10.0	47.7 - 82.3	0.73
^{3}H				
02/22/91	4473 ± 49	4418 ± 442	3651 - 5185	1.01
06/21/91	12200 ± 58	12480 ± 1248	10315 - 14645	0.98
10/18/91	2600 ± 175	2454 ± 352	1843 - 3065	1.06
^{60}Co				
02/08/91	42.0 ± 1.7	40.0 ± 5.0	31.3 - 48.7	1.05
06/07/91	12.0 ± 1.0	10.0 ± 5.0	1.3 - 18.7	1.20
10/04/91	33.3 ± 1.5	29.0 ± 5.0	20.3 - 37.7	1.15
10/22/91	22.3 ± 1.5	20.0 ± 5.0	11.3 - 28.7	1.12
^{65}Zn				
02/08/91	160.7 ± 7.0	149.0 ± 15.0	123.0 - 175.0	1.08
06/07/91	113 ± 7	108 ± 11	89 - 127	1.05
10/04/91	78.3 ± 1.5	73.0 ± 7.0	60.9 - 85.1	1.07
^{89}Sr				
01/11/91	4.3 ± 0.6	5.0 ± 5.0	0.0 - 13.7	0.86
04/16/91	42.7 ± 10.0[e]	28.0 ± 5.0	19.3 - 36.7	1.53
05/10/91	37.0 ± 4.6	39.0 ± 5.0	30.3 - 47.7	0.95
09/13/91	52.0 ± 1.0	49.0 ± 5.0	40.3 - 57.7	1.06
10/22/91	10.7 ± 1.5	10.0 ± 5.0	1.3 - 18.7	1.07
^{90}Sr				
01/11/91	1.3 ± 0.6	5.0 ± 5.0	0.0 - 13.7	0.26
04/16/91	20.0 ± 1.7	26.0 ± 5.0	17.3 - 34.7	0.77
05/10/91	20.3 ± 2.1	24.0 ± 5.0	15.3 - 32.7	0.85
09/13/91	29.0 ± 1.7	25.0 ± 5.0	16.3 - 33.7	1.16
10/22/91	8.00 ± 1.00	10.0 ± 5.0	1.3 - 18.7	0.80
^{106}Ru				
02/08/91	205.7 ± 18.8	186.0 ± 19.0	153.0 - 219.0	1.11
06/07/91	163 ± 10	149 ± 15	123 - 175	1.09
10/04/91	207 ± 7	199.0 ± 20.0	164.3 - 233.7	1.04
^{131}I				
02/15/91	No Data[d]	75.0 ± 8.0	61.1 - 88.9	-----

(a) Average value [± 1 standard deviation(s)] reported by REECo.
(b) The known value (± 1s) reported by EPA/EMSL-LV.
(c) The control limits determined by EPA/EMSL-LV.
(d) No data provided.
(e) The value is outside the control limits determined by EPA/EMSL-LV.
(f) Outliers.

Table 10.1 (Results of EPA/EMSL Nuclear Radiation Assessment and Cross Checks - 1991, cont.)

Analysis/ Date	Water Samples, pCi/L *(cont.)* REECo[a]	EPA/EMSL[b]	Control Limits[c]	Ratio of REECo/ EMSL
^{133}Ba				
02/08/91	71.7 ± 3.8	75.0 ± 8.0	66.1 - 88.9	0.96
06/07/91	60.3 ± 3.1	62.0 ± 6.0	51.6 - 72.4	0.97
10/04/91	98.0 ± 1.7	98.0 ± 10.0	80.7 - 115.3	1.00
^{134}Cs				
02/08/91	9.7 ± 1.2	8.0 ± 5.0	0.0 - 16.7	1.21
04/16/91	25.3 ± 6.7	24.0 ± 5.0	15.3 - 32.7	1.05
06/07/91	15.7 ± 1.5	15.0 ± 5.0	6.3 - 23.7	1.05
10 04/91	9.67 ± 1.15	10.0 ± 5.0	1.3 - 18.7	0.97
10 22/91	8.67 ± 0.58	10.0 ± 5.0	1.3 - 18.7	0.97
^{137}Cs				
02/08/91	9.3 ± 0.6	8.0 ± 5.0	0.0 - 16.7	1.16
04/16/91	30.7 ± 7.4	25.0 ± 5.0	16.3 - 33.7	1.23
06/07/91	18.0 ± 2.0	14.0 ± 5.0	5.3 - 22.7	1.29
10/04/91	13.3 ± 0.6	10.0 ± 5.0	1.3 - 18.7	1.33
10/22/91	13.3 ± 0.6	11.0 ± 5.0	2.3 - 19.7	1.21
^{226}Ra				
03/08/91	33.4 ± 1.3	31.8 ± 4.8	23.5 - 40.1	1.05
04/16/91	3.83 ± 0.40[f]	8.0 ± 1.2	5.9 - 10.1	0.48
07/12/91	15.5 ± 1.6	15.9 ± 2.4	11.7 - 20.1	0.97
10/22/91	22.9 ± 0.9	22.0 ± 3.3	16.3 - 27.7	1.04
11/08/91	5.40 ± 0.46	6.5 ± 1.0	4.8 - 8.2	0.83
^{228}Ra				
03/08/91	13.9 ± 4.1	21.1 + 5.3	11.9 - 30.3	0.66
04/16/91	20.6 ± 1.7	15.2 ± 3.8	8.6 - 21.8	1.36
07/12/91	16.8 ± 1.5	16.7 ± 4.2	9.4 - 24.0	1.01
10/22/91	25.1 + 2.9	22.2 ± 5.6	12.5 - 31.9	1.13
11/08/91	8.57 ± 2.97	8.1 + 2.0	4.6 - 11.6	1.06
^{239}Pu				
01/18/91	3.00 ± 0.17	3.3 ± 0.3	2.8 - 3.8	0.91
08/23/91	19.6 ± 1.0	19.4 ± 1.9	16.1 - 22.7	1.01
^{Nat}U				
03/15/91	6.0 ± 0.1	7.6 ± 3.0	4.1 - 11.1	0.79
04/16/91	26.5 ± 2.6	29.8 ± 3.0	24.6 - 35.0	0.89
07/19/91	9.80 ± 1.60	14.2 ± 3.0	9.0 - 19.4	0.69
10/22/91	10.4 ± 1.6	13.5 ± 3.0	8.3 - 18.7	0.77

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1s) reported by EPA/EMSL-LV.
(c) The control limits determined by EPA/EMSL-LV.
(d) No data provided.
(e) The value is outside the control limits determined by EPA/EMSL-LV.
(f) Outliers.

Table 10.1 (Results of EPA/EMSL Nuclear Radiation Assessment and Cross Checks - 1991, cont.)

Analysis/ Date	Air Filters, pCi/Filter REECo[a]	DOE/EML[b]	Mean[c]	Ratio of REECo/ EMSL
Gross Alpha				
03/29/91	29.0 ± 0. 0	25.0 ± 6.0	14.6 - 35.4	1.16
08/30/91	134 ± 4[f]	25.0 ± 6.0	14.6 - 35.4	5.36
Gross Beta				
03/29/91	108 ± 10[e]	124 ± 6	114 - 134	0.87
08/30/91	100 ± 2	92.0 ± 10.0	74.7 - 109.3	1.09
^{90}Sr				
03/29/91	54.3 ± 5.5[e]	40.0 ± 5.0	31.3 - 48.7	1.36
08/30/91	22.7 ± 1.5	30.0 ± 5.0	21.3 - 38.7	0.76
^{137}Cs				
03/29/91	33.3 ± 2.3	40.0 ± 5.0	31.3 - 48.7	0.83
08/30/91	43.7 ± 0.6[e]	30.0 ± 5.0	21.3 - 38.7	1.46

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1s) reported by EPA/EMSL-LV.
(c) The control limits determined by EPA/EMSL-LV.
(d) No data provided.
(e) The value is outside the control limits determined by EPA/EMSL-LV.
(f) Outliers.

Table 10.2 Results of the DOE/EML Quality Assessment Program - 1991

Analysis/ Date	Air Filters, Bq/Filter REECo[a]	DOE/EML[b]	Mean[c]	Ratio of REECo/ EML
^{7}Be				
09/91	68.4 ± 3.0%	53.8 ± 4.0%	53.7	1.27 ± 0.10
^{54}Mn				
09/91	31.6 ± 0.5%	24.3 ± 3.0%	23.9	1.30 ± 0.05
^{57}Co				
09/91	24.7 ± 1.0%	16.6 ± 4.0%	17.0	1.49 ± 0.07
^{60}Co				
09/91	27.5 ± 0.5%	23.0 ± 4.0%	22.3	1.20 ± 0.05

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1 standard error of the mean [sem]) reported by DOE/EML.
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value.
(d) The range defined by the 99% confidence limits of the REECo value (e.g. REECo value (± 3s) does not include the EML-DOE know value and the ratio of REECo/EML is outside the 0.5-1.5 range.
(e) No data reported.
(f) In units of µg/filter, g, or mL.

Table 10.2 (Results of the DOE/EML Quality Assessment Program - 1991, cont.)

Analysis/ Date	REECo[a]	DOE/EML[b]	Mean[c]	Ratio of REECo/ EML
	Air Filters, Bq/Filter *(cont.)*			
^{90}Sr 09/91	0.507 ± 2.0%	0.663 ±10%	0.638	0.764 ± 0.03
^{137}Cs 09/91	36.4 ± 0.5%	28.0 ± 4.0%	27.7	1.30 ± 0.06
^{144}Ce 09/91	84.5 ± 2.0%[d]	50.8 ± 3.0%	48.3	1.66 ± 0.09
^{239}Pu 09/91	0.0755 ± 14%	0.0840± 0.0%	0.0828	0.90 ± 0.12
^{241}Am 09/91	0.0611 ± 18%	0.104 ± 9.0%	0.0987	0.59 ± 0.17
$^{UG}U^{f}$ 09/91	No Data[e]	3.08 ± 8.0%	3.33	-----
	Soil Samples, Bq/kg			
^{40}K 09/91	345 ± 3.0%	430 ± 2.0%	448	0.80 ± 0.06
^{90}Sr 09/91	No Data[e]	3.78 ± 5.0%	3.54	-----
^{137}Cs 09/91	271 ± 2.0%	312 ± 5.0%	347	0.87 ± 0.06
^{239}Pu 09/91	5.02 ± 6.5%	7.35 ± 7.0%	7.92	0.68 ± 0.11
^{241}Am 09/91	1.34 ± 7.5%	1.58 ± 1.0%	1.51	0.85 ± 0.13
$^{UG}U^{(f)}$ 09/91	No Data[e]	2.28 ± 4.0%	2.00	-----

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1 standard error of the mean [sem]) reported by DOE/EML.
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value.
(d) The range defined by the 99% confidence limits of the REECo value (e.g. REECo value (± 3s) does not include the EML-DOE know value and the ratio of REECo/EML is outside the 0.5-1.5 range.
(e) No data reported.
(f) In units of µg/filter, g, or mL.

Table 10.2 (Results of the DOE/EML Quality Assessment Program - 1991, cont.)

Analysis/ Date	REECo[a]	DOE/EML[b]	Mean[c]	Ratio of REECo/ EML
Vegetation Samples, Bq/kg				
^{40}K 09/91	892 ± 0.5%	992 ± 1.0%	1050	0.90 ± 0.02
^{90}Sr 09/91	292 ± 2.5%	439 ± 7.0%	359	0.67 ± 0.06
^{137}Cs 09/91	24.9 ± 3.5%	27.1 ± 1.0%	29.6	0.92 ± 0.07
^{239}Pu 09/91	0.466 ± 11%	0.365 ±11%	0.352	1.28 ± 0.10
^{241}Am 09/91	No Data[e]	0.266 ±22%	0.254	-----
Water Samples, Bq/Kg				
^{3}H 09/91	91.0 ± 3.0%	100 ± 2.0%	100	0.91 ± 0.06
^{54}Mn 09/91	117 ± 5.5%	103 ± 3.0%	106	1.14 ± 0.13
^{57}Co 09/91	192 ± 2.0%	166 ± 4.0%	174	1.16 ± 0.07
^{60}Co 09/91	325 ± 0.5%	291 ± 3.0%	305	1.12 ± 0.04
^{90}Sr 09/91	No Data[e]	10.1 ± 5.0%	10.5	-----
^{137}Cs 09/91	56.2 ± 3.0%	46.0 ± 3.0%	49.2	1.22 ± 0.09
^{144}Ce 09/91	512 ± 2.5%[d]	226 ± 4.0%	228	2.27 ± 0.16
^{239}Pu 09/91	0.529 ± 2.0%	0.510 ± 5.0%	0.490	1.04 ± 0.04
^{241}Am 09/91	0.501 ± 5.0%	0.570 ±10%	0.550	0.88 ± 0.08
^{UG}U[f] 9/91	No Data[e]	0.0370± 4.0%	0.0398	-----

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1 standard error of the mean [sem]) reported by DOE/EML.
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value.
(d) The range defined by the 99% confidence limits of the REECo value (e.g. REECo value (± 3s) does not include the EML-DOE know value and the ratio of REECo/EML is outside the 0.5-1.5 range.
(e) No data reported.
(f) In units of µg/filter, g, or mL.

11.0 ONSITE NONRADIOLOGICAL QUALITY ASSURANCE

Kevin R. Krenzien

The nonradiological quality assurance (QA) program included sample acceptance and control criteria, quality control (QC) procedures, and interlaboratory comparisons through participation in the National Institute of Occupational Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program, the American Industrial Hygiene Association (AIHA) Asbestos Analysts Registry (AAR) Program, the AIHA Bulk Asbestos Analysis Program, National Voluntary Laboratory Accreditation Program (NVLAP) Bulk Asbestos Fiber Analysis Program, and the College of American Pathologists (CAP) Analysis of Lead in Blood Program. Proficiency testing through participation in the EPA Contract Laboratory Program (CLP) was continued.

11.1 OVERVIEW OF THE ONSITE NONRADIOLOGICAL QUALITY ASSURANCE PROGRAM

Onsite nonradiological samples were analyzed by Reynolds Electrical & Engineering Co., Inc. (REECo), and three commercial laboratories during 1991. Most of the environmental samples requiring organic analyses were sent to CLP laboratories: Datachem Laboratories in Salt Lake City, or Sierra Technical Services in Las Vegas. Nonradiological samples included industrial hygiene air monitoring samples, asbestos monitoring program samples, environmental water and soil samples, and PCB samples.

The quality of the analytical data and results produced was assured with a program which included calibration of all instrumentation, use of standard analytical procedures, the inclusion and analysis of QC samples, and continuation of personnel training to maintain qualified staff. Prior to release, all analytical results were reviewed and compared to accepted QC data.

The onsite industrial hygiene laboratory continued to participate in a number of external quality assurance programs and maintained all external agency accreditations while progressing to achieve EPA CLP equivalency.

The QA program included:

- Specific sample acceptance criteria and maintenance of sample custody
- Calibration of all analytical instrumentation
- A program of preventative and periodic maintenance for all systems which were crucial to data quality
- Use of National Institute of Standards and Technology (NIST) or EPA-traceable standards and reference materials

- Spikes, blanks, and blind replicates as QC samples, used to assess measurement quality
- Review of QC charts to assure control of methods and processes
- Review of analytical data before final results were released

The onsite laboratory participated in QA programs operated by the AIHA, NIST, NIOSH, and EPA.

11.2 SAMPLE ACCEPTANCE AND CONTROL

Samples submitted to the onsite industrial hygiene laboratory included a Chain of Custody Form and an appropriate Sample Data Sheet before they were accepted by the sample custodian. The sample custodian also checked the sample to ensure proper collection procedures were used, samples were transported correctly (i.e., organic samples were refrigerated), and sample holding times were not exceeded. If the samples met the laboratory sample acceptance criteria, they were logged into the Sample and Analysis Management System (SAM). The samples were then stored in a locked, walk-in cooler until a chemist was ready to analyze the samples. If a sample was not destroyed during analysis, it was returned to the walk-in cooler for storage and future disposal. All sample transactions continued to be documented using the field-generated Chain of Custody Form.

11.3 QUALITY CONTROL

A program of daily, weekly, and monthly preventative maintenance was followed. This program included monitoring of laboratory water quality, monitoring of refrigerator temperatures, and verifying the accuracy of analytical balances and equipment. The preventative maintenance program also included periodic instrument service by manufacturer service engineers. A maintenance logbook and a separate sample run logbook were maintained for each analytical instrument.

Analytical instrumentation was calibrated before the analysis of a sample batch. A multi-standard calibration curve had to exhibit a correlation coefficient of 0.995 or greater before the analytical data could be reported.

Check samples were run periodically throughout a sample batch. These analyses insured that the instrument calibration remained valid during the batch analysis.

Trip, field, holding, and method blanks were analyzed to insure that cross-contamination did not affect the final analytical result.

Spikes to measure analytical recovery were analyzed at a rate of 1 in 10 samples. The spike results were plotted on QC charts and had to fall within three standard deviations of a population mean before sample results were verified. If the spike results did not meet this criterion, the root cause was determined,corrective actions taken, and the sample batch was reanalyzed if the holding time was still valid.

Sample replicates were also prepared and analyzed at a rate of 1 in 10 samples. The relative percent difference (RPD) was calculated for the replicate samples and plotted on QC charts. The RPD had to be within three standard deviations of the population mean before the sample

results were approved. The sample batch was reanalyzed if this criterion was not met. Before being released, all sample data and results underwent three levels of review: (1) peers reviewed the sample data for errors involving standard preparation and calculations, (2) the quality coordinator reviewed the data and results to assure that all QC criteria had been met, and (3) the laboratory supervisor reviewed the data and results before certifying and transmitting the final results.

11.3.1 INTERLABORATORY COMPARISON PROGRAMS

The external QA/QC program included participation in the NIOSH PAT program, AIHA AAR program, AIHA Bulk Asbestos Analysis Program, NIST NVLAP Bulk Asbestos Fiber Analysis Program, and CAP Analysis of Lead in Blood Program. Participation in the EPA CLP quarterly proficiency testing program was continued.

All of these programs required participating laboratories to analyze proficiency samples at various intervals throughout the year.

The standard sample matrices (air monitoring filters, bulk asbestos samples, blood samples, soil, and water) were prepared by external reference agencies and contained one or more analytes in concentrations which were unknown to the participating laboratories. After the results were analyzed, they were forwarded to the sponsoring agency for comparison to the reference value and the results of other participating laboratories. These programs served to identify analytical problems requiring corrective action.

Tables 11.1, 11.2, and 11.3 are summaries of interlaboratory comparison results during 1991. Performance limits for these interlaboratory comparisons are set at plus or minus three normalized standard deviations for the participating laboratories. As asbestos fiber analytical results are qualitative and based on identification, no results are given for either the AIHA or NVLAP bulk asbestos programs. However, the industrial hygiene laboratory continued to maintain its accreditation in both of these programs. The results were generally within performance limits required by the sponsoring agencies. Causes for results which were not within acceptable performance limits were investigated, and corrective actions were taken to prevent reoccurrence. Corrective actions taken included analyzing past proficiency samples along with current proficiency samples to assess data quality, improving the dissolution process for silica analysis to improve low recoveries, improving training of gas chromatograph operator, and increasing the level of data review.

11.4 RECENT DEVELOPMENTS IN QA/QC PROGRAM

The reorganization of the REECo Health Physics Laboratory and Industrial Hygiene Laboratory into the Analytical Services Department (ASD) influenced programmatic changes in the QA activities of the ASD. The reorganization of the ASD included the creation of a central quality support group. The mission of the Analytical Services Department (ASD) Quality Support Group (QSG) is to support the analytical capabilities of the ASD by performing ASD surveillances and management assessments; documenting and coordinating ASD indoctrination and training; coordinating responses to external audits and surveillances; tracking action items within the ASD; preparing independent quality control samples; coordinating review and revisions to ASD Standard Operating Procedures (SOPs); controlling SOPs by document control activities; administering the ASD laboratory intercomparison QA

performance evaluation program; performing vendor audits of laboratory subcontractors; and overseeing the ASD Chemical Hygiene and Radiation Safety program. These activities are planned and structured to meet the requirements of DOE Orders, the REECo Quality Assurance Program, and ASD Quality Procedures.

Table 11.1 NIOSH PAT Program Interlaboratory Comparison - 1991

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
Cd (in mg)				
02/27/91	0.0097	0.0092	1.05	0.0083-0.0101
	0.0122	0.0118	1.03	0.0105-0.0131
	0.0151	0.0149	1.01	0.0134-0.0163
	0.0169	0.0168	1.01	0.0151-0.0184
05/24/91	0.0122	0.0139	0.88[c]	0.0124-0.0154
	0.0061	0.0070	0.87[c]	0.0062-0.0077
	0.0178	0.0197	0.90	0.0178-0.0216
	0.0100	0.0110	0.91	0.0098-0.0121
08/20/91	0.0134	0.0123	1.09	0.0108-0.0138
	0.0115	0.0100	1.15[c]	0.0087-0.0113
	0.0068	0.0061	1.11	0.0053-0.0069
	0.0175	0.0166	1.05	0.0147-0.0186
11/22/91	0.0086	0.0090	0.96	0.0080-0.0099
	0.0048	0.0051	0.94	0.0044-0.0057
	0.0122	0.0129	0.95	0.0114-0.0143
	0.0104	0.0109	0.95	0.0097-0.0121
Pb (in mg)				
02/27/91	0.0385	0.0358	1.08	0.0319-0.0397
	0.0813	0.0779	1.04	0.0694-0.0863
	0.0478	0.0446	1.07	0.0405-0.0487
	0.0648	0.0612	1.06	0.0546-0.0678
05/24/91	0.0443	0.0464	0.95	0.0414-0.0514
	0.0550	0.0557	0.99	0.0495-0.0618
	0.0228	0.0243	0.94	0.0216-0.0270
	0.0338	0.0348	0.97	0.0307-0.0389
08/20/91	0.0613	0.0601	1.02	0.0541-0.0660
	0.0333	0.0300	1.11[c]	0.0267-0.0332
	0.0900	0.0849	1.06	0.0761-0.0937
	0.0520	0.0494	1.05	0.0449-0.0538
11/22/91	0.0243	0.0247	0.98	0.0219-0.0275
	0.0496	0.0493	1.01	0.0443-0.0543
	0.0734	0.0734	1.00	0.0664-0.0804
	0.0586	0.0589	0.99	0.0535-0.0664

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) Outliers.

Table 11.1 (NIOSH PAT Program Interlaboratory Comparison - 1991, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
Zn (in mg)				
02/27/91	0.1538	0.1505	1.02	0.1328-0.1682
	0.1148	0.1115	1.03	0.0930-0.1300
	0.2170	0.2125	1.02	0.1916-0.2334
	0.1815	0.1770	1.03	0.1562-0.1978
05/24/91	0.1333	0.1356	0.98	0.1223-0.1489
	0.0728	0.0779	0.93	0.0678-0.0879
	0.2045	0.2064	0.99	0.1815-0.2313
05/24/91	0.1610	0.1627	0.99	0.1429-0.1826
11/22/91	0.0923	0.0941	0.98	0.0836-0.1046
	0.0741	0.0746	0.99	0.0649-0.0843
	0.1172	0.1194	0.98	0.1050-0.1339
	0.1718	0.1737	0.99	0.1564-0.1910
Silica (in mg)				
02/27/91	0.1169	0.1160	1.01	0.0586-0.2299
	0.0935	0.1006	0.93	0.0476-0.2128
	0.0644	0.0885	0.73	0.0475-0.1648
	0.0486	0.0654	0.74	0.0312-0.1372
05/24/91	0.0838	0.1010	0.83	0.0457-0.2234
	0.0578	0.0685	0.84	0.0329-0.1426
	0.0653	0.0674	0.96	0.0305-0.1487
	0.0431	0.0837	0.51	0.0355-0.1971
08/20/91	0.0372	0.0737	0.50	0.0304-0.1789
	0.0381	0.0844	0.45[c]	0.0424-0.1684
	0.0606	0.1192	0.51[c]	0.0675-0.2106
	0.0403	0.1353	0.30[c]	0.0643-0.2851
11/22/91	0.1368	0.1538	0.89	0.0822-0.2879
	0.1372	0.1183	1.16	0.0658-0.2128
	0.0848	0.1019	0.83	0.0612-0.1696
	0.1185	0.1056	1.12	0.0534-0.2092
Asbestos (in fibers/mm^2)				
02/27/91	296	238	1.24	107.6 - 419.5
	860	603.5	1.43	320.2 - 975.8
	1072	838.4	1.28	455.2 -1337.7
	625	416.3	1.50	191.6 - 727
05/24/91	655	745.6	0.88	411.7 -1177.9
	590	592.6	0.99	289.9 -1002.4
	206	224.3	0.92	99.7 - 398.7
	357	320.2	1.11	153.5 - 547.5

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) Outliers.

Table 11.1 (NIOSH PAT Program Interlaboratory Comparison - 1991, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
(Asbestos cont.)				
08/20/91	214	231.1	0.93	115.8-385.9
	618	408.5	1.51	224.1-647.8
	1094	805.6	1.36	422.2-1311.8
	764	657.6	1.16	368.8-1029.2
11/22/91	250	296.3	0.84	82.4-642.7
	308	238.7	1.29	69.1-510.2
	451	402.7	1.12	155.9-764.6
	651	668.1	0.97	303.4-1175
		Solvents[c]		
MCM (in mg)				
02/27/91	1.0546	1.0121	1.04	0.8694-1.1547
	0.4747	0.5112	0.93	0.4383-0.5839
	0.9186	0.8764	1.05	0.7646-0.9882
	1.1373	1.2244	0.93	1.0862-1.3625
PCE (in mg)				
02/27/91	0.5747	0.5678	1.01	0.4798-0.6557
	0.8254	0.8797	0.94	0.7584-1.0010
	1.1041	1.0753	1.03	0.9336-1.2169
	0.3864	0.4294	0.90	0.3676-0.4911
TCE (in mg)				
02/27/91	0.4800	0.4771	1.01	0.4189-0.5353
	0.6789	0.7274	0.93	0.6418-0.8129
	0.9592	0.9451	1.01	0.8416-1.0485
	0.7235	0.8049	0.90	0.7130-0.8968
11/22/91	0.8194	0.9064	0.90	0.7820-1.0308
	0.4386	0.5177	0.85[d]	0.4498-0.5857
	0.9586	1.0936	0.88	0.9415-1.2457
	0.6876	0.7079	0.97	0.6284-0.7873
CFM (in mg)				
05/24/91	0.4749	0.4937	0.96	0.4237-0.5637
	1.0950	1.1172	0.98	0.9775-1.2568
	0.6419	0.6446	0.99	0.5636-0.7255
	0.7884	0.8139	0.97	0.7215-0.9064

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) Solvent abbreviations:CTC=Carbon Tetrachloride, DCE=1,2 Dichloroethane, MCM=1,1,1-Trichloroethane, PCE=Tetrachloroethylene, TCE=Trichloroethylene, CFM=Chloroform
(d) Outliers.

Table 11.1 (NIOSH PAT Program Interlaboratory Comparison - 1991, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
		Solvents[c] *(cont.)*		
CTC (in mg)				
05/24/91	0.5901	0.6094	0.97	0.5325-0.6863
	1.3669	1.3941	0.98	1.2547-1.5335
	0.9582	0.9685	0.99	0.8549-1.0820
	1.0548	1.0979	0.96	0.9732-1.2225
11/22/91	0.9732	1.0459	0.93	0.9069-1.1849
	0.6418	0.7349	0.87	0.6310-0.8388
	0.3952	0.4216	0.94	0.3449-0.4983
	1.2674	1.2862	0.99	1.1219-1.4505
DCE (in mg)				
05/24/91	0.8967	0.9101	0.99	0.8164-1.0037
	0.8234	0.8343	0.99	0.7463-0.9223
	0.4463	0.4492	0.94	0.3998-0.4985
	0.6853	0.7042	0.97	0.6282-0.7801
11/22/91	0.8291	0.9289	0.89	0.8230-1.0347
	0.6101	0.7369	0.83[d]	0.6450-0.8288
	1.0120	1.1655	0.87[d]	1.0159-1.3152
	0.6660	0.6918	0.96	0.6194-0.7641
BNZ (in mg)				
08/20/91	0.1021	0.0926	1.10	0.0746-0.1105
	0.1759	0.1774	0.99	0.1519-0.2028
	0.2238	0.2265	0.99	0.1988-0.2541
	0.2566	0.2545	1.01	0.2191-0.2900
OXY (in mg)				
08/20/91	1.3063	1.6014	0.82[d]	1.3560-1.8468
	1.1040	1.2698	0.87	1.0834-1.4562
	0.8889	1.0270	0.87	0.8799-1.1741
	0.6400	0.7036	0.91	0.6068-0.8005
TOL				
08/20/91	0.5967	0.7084	0.84	0.5854-0.8315
	0.8707	0.9961	0.87[d]	0.8752-1.1171
	1.0867	1.2135	0.90	1.0568-1.3702
	1.2002	1.2897	0.93	1.1471-1.4322

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) Solvent abbreviations:CTC=Carbon Tetrachloride, DCE=1,2 Dichloroethane, MCM=1,1,1-Trichloroethane, PCE=Tetrachloroethylene, TCE=Trichloroethylene, CFM=Chloroform
(d) Outliers.

Table 11.2 CAP Program Interlaboratory Comparison - 1991

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
Blood Pb (in µg/dL)				
05/5/91	49.8	55.28	0.90	46.9 - 63.6
	8.5	13.03	0.65	7.0 - 19.1
	50.8	55.45	0.92	47.1 - 63.8
	9.3	13.16	0.70	7.1 - 19.2
	48.3	55.12	0.88	46.8 - 63.4
08/3/91	13.5	10.51	1.28	4.5 - 16.6
	21.4	20.39	1.05	14.3 - 26.4
	12.8	10.08	1.27	4.0 - 16.1
	14.2	10.36	1.37	4.3 - 16.4
	10.5	9.88	1.06	3.8 - 15.9
10/26/91	19.5	20.73	0.94	14.7 - 26.8
	36.3	38.50	0.94	32.5 - 44.5
	43.5	44.96	0.97	38.2 - 51.7
	18.3	21.04	0.87	15.0 - 27.1
	37.8	38.28	0.99	32.2 - 44.3
01/11/92	25.8	28.37	0.91	22.3 - 34.4
	27.8	28.46	0.98	22.4 - 34.5
	26.8	28.62	0.94	22.6 - 34.7
	26.5	28.69	0.92	22.6 - 34.7
	25.3	28.68	0.82	22.6 - 34.7

(a) Value provided by the CAP Blood Lead Survey Program.
(b) Ratio = REECo Result/Reference value.

Table 11.3 AAR Program Interlaboratory Comparison - 1991

Analysis and Date	REECo Result[a]	Reference Value[b]	Ratio[c]	Performance Limits[b]
Quantitative Asbestos (in fibers/mm^2)				
04/18/91	398	441	0.90	220 - 882
	448	441	1.02	220 - 882
	435	441	0.99	220 - 882
	484	441	1.09	220 - 882
	495	541	0.91	271 - 1082

(a) Individual analyst results reported by REECo.
(b) Value(s) provided by AAR.
(c) Ratio = REECo Result/Reference Value.
(d) REECo reported result was outside program performance limits.

Table 11.3 (AAR Program Interlaboratory Comparison - 1991, cont.)

Analysis and Date	REECo Result[a]	Reference Value[b]	Ratio[c]	Performance Limits[b]
Quantitative Asbestos (cont.)				
(04/18/91, cont.)	557	541	1.03	271 - 1082
	527	541	0.97	271 - 1082
	562	541	1.04	271 - 1082
	576	636	0.90	318 - 1271
	514	636	0.81	318 - 1271
	604	636	0.95	318 - 1271
	566	636	0.89	318 - 1271
	317	317	1.00	159 - 634
	311	317	0.98	159 - 634
	345	317	1.09	159 - 634
	320	317	1.01	159 - 634
08/23/91	527	568	0.93	284 - 1136
	455	568	0.97	284 - 1136
	541	568	0.95	284 - 1136
	535	568	0.94	284 - 1136
	342	469	0.73	234 - 937
	344	469	0.73	234 - 937
	404	469	0.86	234 - 937
	417	469	0.89	234 - 937
	168	241	0.70	121 - 483
	232	241	0.96	121 - 483
	225	241	0.93	121 - 483
	322	349	0.92	175 - 698
	368	349	1.05	175 - 698
	284	349	0.81	175 - 698
(AAR Round 19) - NO INFORMATION				
(AAR Round 20) - AWAITING RETURN OF REPORT				
	306			
	245			
	92			
	344			
	297			
	294			
	68			
	468			
	285			
	291			
	103			
	587			

(a) Individual analyst results reported by REECo.
(b) Value(s) provided by AAR.
(c) Ratio = REECo Result/Reference Value.
(d) REECo reported result was outside program performance limits.

12.0 OFFSITE RADIOLOGICAL QUALITY ASSURANCE

David G. Easterly and Deb J. Chaloud

The policy of the U.S. Environmental Protection Agency (EPA) requires participation in a centrally managed quality assurance program (QA) by all EPA organizational units involved in environmental data collection. The QA program developed by the Nuclear Radiation Assessment Division (NRD) of the Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV) for the Offsite Radiological Safety Program (ORSP) meets all requirements of EPA policy, and also includes applicable elements of the Department of Energy (DOE) QA requirements and regulations. The ORSP QA program defines data quality objectives (DQOs), which are statements of the quality of data a decision maker needs to ensure that a decision based on that data is defensible. Achieved data quality may then be evaluated against these DQOs. This chapter describes the DQOs and the achieved data quality for the ORSP in 1991.

12.1 POLICY

One of the major goals of the U.S. Environmental Protection Agency (EPA) is to ensure that all EPA decisions which are dependent on environmental data, are supported by data of known quality. Agency policy initiated by the Administrator in memoranda of May 30, 1979, and June 14, 1979, requires participation in a centrally managed Quality Assurance (QA) Program by all EPA Laboratories, Program Offices, Regional Offices, and those monitoring and measurement efforts supported or mandated through contracts, regulations, or other formalized agreements. Further, by EPA Order 5360.1, Agency policy requires participation in a QA Program by all EPA organizational units involved in environmental data collection.

The QA policies and requirements of EPA's Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) are summarized in the *Quality Assurance Program Plan* (EPA 1987). Policies and requirements specific to the Offsite Radiological Safety Program (ORSP) are documented in the *Quality Assurance Program Plan for the Nuclear Radiation Assessment Division Offsite Radiation Safety Program* (EPA, in preparation). The requirements of these documents establish a framework for consistency in the continuing application of quality assurance standards and implementing procedures in support of the ORSP. Administrative and technical implementing procedures based on these QA requirements are maintained in appropriate manuals or are described in standard operating procedures (SOP). It is NRD policy that personnel adhere to the requirements of the QA Plan and all SOPs applicable to their duties to ensure that all environmental radiation monitoring data collected by the EPA EMSL-LV in support of the ORSP are of adequate quality and properly documented for use by the DOE, EPA, and other interested parties.

12.2 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are statements of the quality of data a decision maker needs to ensure that a decision based on that data is defensible. Data quality objectives are defined in terms of representativeness, comparability, completeness, precision, and accuracy. Representativeness and comparability are generally qualitative assessments while completeness, precision, and accuracy may be quantitatively assessed. In the ORSP, representativeness, comparability, and completeness objectives are defined for each monitoring network. Precision and accuracy are defined for each analysis type or radionuclide.

Achieved data quality is monitored continuously through internal QC checks and procedures. In addition to the internal quality control procedures, NRD participates in external intercomparison programs. One such intercomparison program is managed and operated by a group within EPA EMSL-LV. These external performance audits are conducted as described in and according to the schedule contained in "Environmental Radioactivity Laboratory Intercomparison Studies Program" (EPA, 1981). The analytical laboratory also participates in the DOE Environmental Measurements Laboratory (EML) Quality Assurance Program in which real or synthetic environmental samples that have been prepared and thoroughly analyzed are distributed to participating laboratories. Periodic (every two or three years) external systems and performance audits are conducted for the TLD network as part of the certification requirements for DOE's Laboratory Accreditation Program (DOELAP). Bone ash samples spiked with a known amount of radioactivity are submitted to the contract laboratory with each set of animal tissue samples. These external intercomparison and audit programs are used to monitor analysis accuracy.

12.2.1 REPRESENTATIVENESS, COMPARABILITY, AND COMPLETENESS OBJECTIVES

Representativeness is defined as "the degree to which the data accurately and precisely represent a characteristic of a parameter, variation of a property, a process characteristic, or an operation condition" (Stanley and Verner, 1985). In the ORSP, representativeness may be considered to be the degree to which the collected samples represent the radionuclide activity concentrations in the offsite environment. Collection of samples from all media which are possible pathways to human exposure as well as direct measurement of offsite resident exposure through the TLD and internal dosimetry monitoring programs provides assurance of the representativeness of the calculated exposures.

Comparability is defined as "the confidence with which one data set can be compared to another" (Stanley and Verner, 1985). Comparability of data is assured by use of SOPs for sample collection, handling, and analysis; use of standard reporting units; and use of standardized procedures for data analysis and interpretation. In addition, another aspect of comparability is examined through long term comparison and trend analysis of various radionuclide activity concentrations, TLD and PIC data. Use of SOPs, maintained under a document control system, is an important component of comparability, ensuring that all personnel conform to a unified set of procedures.

Completeness is defined as "a measure of the amount of data collected from a measurement process compared to the amount that was expected to be obtained under the conditions of measurement" (Stanley and Verner, 1985). Data may be lost due to instrument malfunction,

sample destruction, loss in shipping or analysis, analytical error, or unavailability of samples. Additional data values may be deleted due to unacceptable precision, accuracy, or detection limit or as the result of application of statistical outlier tests. The completeness objective for all networks except the LTHMP is 90%. The completeness objective for the LTHMP is 80%; a lower objective has been established because dry wells or access restrictions occasionally preclude sample collection.

12.2.2 PRECISION AND ACCURACY OBJECTIVES OF RADIOANALYTICAL ANALYSES

Measurements of sample volumes should be accurate to ± 5% for aqueous samples (water and milk) and to ± 10% for air and soil samples. The sensitivity of radiochemical and gamma spectrometric analyses must allow no more than a 5 percent risk of either a false negative or false positive value. Precision to a 95% confidence interval, monitored through analysis of duplicate and blind samples, must be within ± 10% for activities greater than 10 times the minimum detectable activity (MDA) and ± 30% for activities greater than the MDA but less than 10 times the MDA. There are no precision requirements for activity concentrations below the MDA, which by definition, cannot be distinguished from background at the 95% confidence interval. Control limits for accuracy, monitored with matrix spike samples, is required to be no greater than ± 20% for all gross alpha, gross beta, and gamma spectrometric analyses, depending upon the media type.

At concentrations greater than 10 times the MDA, precision is required to be within ± 10% for:

- Conventional Tritium Analyses
- Uranium
- Thorium (all media)
- Strontium

and within ± 20% for:

- Enriched Tritium Analyses
- Strontium (in milk)
- Noble Gases
- Plutonium.

At concentrations less than 10 times the MDA, both precision and accuracy are expressed in absolute units, not to exceed 30% of the MDA for all analyses and all media types.

12.2.3 QUALITY OF EXPOSURE ESTIMATES

The allowable uncertainty of the effective dose equivalent to any human receptor is ± 0.1 mrem annually. This uncertainty objective is based solely upon the precision and accuracy of the data produced from the surveillance networks and does not apply to uncertainties in the model used, effluent release data received from DOE, or dose conversion factors. Generally, effective dose equivalents must have an accuracy (bias) of no greater than 50% for annual exposures greater than or equal to 1 mrem but less than 5 mrem and no greater than 10% for annual exposures greater than or equal to 5 mrem.

12.3 DATA VALIDATION

Data validation is defined as "A systematic process for reviewing a body of data against a set of criteria to provide assurance that the data are adequate for their intended use. Data validation consists of data editing, screening, checking, auditing, verification, certification, and review" (Stanley et al, 1983). Data validation procedures are documented in SOPs. All data are reviewed and checked at various steps in the collection, analysis, and reporting processes.

The first level of data review consists of sample tracking; e.g., that all samples planned to be collected are collected or reasons for non-collection are documented, that all collected samples are delivered to Sample Control and are entered into the appropriate data base management system, and that all entered information is accurate. Next, analytical data are reviewed by the analyst and by the laboratory supervisor. Checks at this stage include verifying that all samples received from Sample Control have been analyzed or reasons for non-analysis have been documented, that data are "reasonable" (e.g., within expected range), and that instrumentation operational checks indicate the analysis instrument is within permissible tolerances. Discrepancies indicating collection instrument malfunction are reported to the Field Operations Branch. Analytical discrepancies are resolved; individual samples or sample batches may be reanalyzed if required.

Raw data are reviewed by a designated media expert. A number of checks are made at this level, including:

- Completeness--all samples scheduled to be collected have, in fact, been collected and analyzed or the data base contains documentation explaining the reasons for non-collection or non-analysis

- Transcription errors--checks are made of all manually entered information to ensure that the information contained in the data base is accurate

- Quality control data--field and analytical duplicate, audit sample, and matrix blank data are checked to ensure the collection and analytical processes are within specified QC tolerances

- Analysis schedules--lists of samples awaiting analysis are generated and checked against normal analysis schedules to identify backlogs in analysis or data entry

- Unidentified malfunctions--sample results and diagnostic graphics of sample results are reviewed for reasonableness. Conditions indicative of instrument malfunction are reported to Field and/or Laboratory Operations

Once the data base has been finalized, the data are compared to the DQOs. Completeness, accuracy, and precision statistics are calculated. The achieved quality of the data is reported annually, at a minimum. If data fail to meet one or more of the established DQOs, the data may still be used in data analysis; however, the data and any interpretive results are to be qualified.

All sample results exceeding the traditional-natural background activity range are investigated. If data are found to be associated with a non-environmental condition, such as a check of the

All sample results exceeding the traditional-natural background activity range are investigated. If data are found to be associated with a non-environmental condition, such as a check of the instrument using a calibration source, the data are flagged and are not included in calculations of averages, etc. Only data verified to be associated with a non-environmental condition are flagged; all other data are used in calculation of averages and other statistics, even if the condition is traced to a source other than the NTS (for example, higher-than-normal activities were observed for several radionuclides following the Chernobyl accident). When activities exceeding the expected range are observed for one network, the data for the other networks at the same location are checked. For example, higher-than-normal-range PIC values are compared to data obtained by the air, noble gas, TLD, and tritium-in-air samplers at the same location.

Data are also compared to previous years' data for the same location using trend analysis techniques. Other statistical procedures may be employed as warranted to permit interpretation of current data as compared to past data. Future trends may also be predicted. Trend analysis is made possible due to the length of the sampling history which, in some cases, is 30 years or longer.

Data from the offsite networks are used, along with NTS source emission estimates prepared by DOE, to calculate or estimate annual committed effective dose equivalents to offsite residents. Surveillance network data are the primary tools for the dose calculations. Additionally, CAP88-PC is used with local meteorological data to predict doses to offsite residents from NTS source term estimates. An assessment of the uncertainty of the dose estimate is made and reported with the estimate.

12.4 QUALITY ASSESSMENT OF 1991 DATA

Data quality assessment is associated with the regular QA and QC practices within the radioanalytical laboratory. The analytical quality control plan, documented in SOPs, proscribes specific procedures used to demonstrate that data are within prescribed requirements for accuracy and precision. Duplicate samples are collected or prepared and analyzed in the exact manner as the regular samples for that particular type of analysis. Data obtained from duplicate analyses are used for determining the degree of precision for each individual analysis. Accuracy is assessed by comparison of data from spiked samples with the "true" or accepted values. Spiked samples are either in-house laboratory blanks spiked with known amounts of radionuclides, or QC samples prepared by other organizations in which data are compared between several laboratories and assessed for accuracy.

On a quarterly and annual basis, achieved data quality statistics are compiled. This data quality assessment is performed as part of the process of data validation, described in Section 12.3. The following subsections describe the achieved data quality for 1991.

12.4.1 COMPLETENESS

Completeness is calculated as:

$$\%C = \left(\frac{V}{n}\right) 100$$

where
%C = percent completeness
V = number of measurements judged valid
n = total number of measurements

The percent completeness of the 1991 data is given in Table 12.1. Reasons for sample loss include instrument malfunction, inability to gain site access, monitoring technician error, or laboratory error. Completeness is not applicable to the Internal Dosimetry Network, as all individuals who request a whole body or lung count receive one, resulting in a completeness of 100 percent, by definition. Completeness statistics are not available for the TLD network.

The achieved completeness of over 93 percent for the LTHMP exceeds the DQO of 80 percent; however, if the wells which have been shut down by DOE are included, the achieved completeness drops to 75 percent for the LTHMP overall and 54 percent for sites sampled on the NTS.

The completeness achieved overall in the ASN was 99.3 percent. There were no data gaps for twenty three stations (100 percent completeness). All of the ASN stations had data recoveries greater than 90 percent for 1991, exceeding the DQO of 90 percent completeness.

Table 12.1 Data Completeness of Offsite Radiological Safety Program Networks

Network	No. of Sampling Locations	Total Samples Possible	Valid Samples Collected	Percent Completeness
LTHMP	256[a]	466[a]	436	93.6[a]
Air Surveillance	33 18 (^{238,239}Pu)	11,722 days[b] 109	11,640 106	99.3 97.2
Noble Gas	21	6133 days[b]	5243 (^{85}Kr) 5309 (^{133}Xe)	85.5 (^{85}Kr) 86.6 (^{133}Xe)
Tritium in Air	20	6670 days[b]	6460	96.9
Milk Surveillance	25	277	223	80.5
Animal Investigation	3	12[c]	12	100.0
PIC	29	1508 weeks[d]	1496	99.2

(a) Does not include wells which have been shut down by DOE (see Section 9.2.2)

(b) Continuous samplers with samples collected at intervals of approximately one week. Days used as units to account for differences in sample interval length.

(c) Includes four mule deer from the Nevada Test Site and four cows from each of two locations. Does not include bighorn sheep, fruits and vegetables, and other animals which are "samples of opportunity."

(d) Continuous samplers with data summarized on a weekly basis.

The achieved completeness for plutonium isotopes in air was 97.2 percent, greater than the DQO of 90 percent. All but three sites achieved a 100 percent recovery. Two states in the standby network failed to collect samples in one quarter and one composite sample from Amargosa Valley was lost in chemistry.

The achieved completeness for the noble gas network overall was less than the DQO of 90 percent. A new model of sampler was installed at each station in the spring of 1991. These new units exhibited a number of malfunctions in the first several months of operation, resulting in low sample recovery. The only stations to meet or exceed the 90 percent DQO on an individual basis were Beatty, Goldfield, Indian Springs, and Overton, Nevada. The standby station at Delta, Utah achieved a 100 percent recovery for the 26 days it was in operation. Due to sample loss in the Radioanalysis Laboratory, the achieved recovery for the St. George, Utah station was greater than 90 percent for ^{133}Xe, but less than 90 percent for ^{85}Kr. Completeness was less than 75 percent for noble gases at Austin and Amargosa Valley Community Center, Nevada and Milford and Salt Lake City, Utah; consequently, the samples cannot be considered representative of activities at these sites for 1991.

Each of the tritium-in-air stations achieved sample recoveries of greater than the 90 percent DQO. Completeness was 100 percent at eight stations: Shoshone, California and Austin, Caliente, Las Vegas, Overton, Pahrump, Pioche, and Twin Springs, Nevada. The tritium-in-air sampler was installed at Twin Springs in November; therefore, even though sample recovery was 100 percent for the period of operation, the activities cannot be considered to be representative of all of 1991.

Overall completeness for the MSN was 80.5 percent. Samples were obtained every month (i.e., 100 percent recovery) from 14 of the 25 sampling locations. Another two sites had an achieved completeness of greater than the DQO of 90 percent. Three of the family-owned cow or goat sampling locations yielded no samples in 1991 (i.e., 0 percent completeness) and another two had an achieved completeness of 50 percent or less. In the majority of the cases, samples could not be collected because the cow or goat was unable to produce milk.

In the Animal Investigation program, one mule deer is harvested each quarter from the NTS. Four cows are purchased in the spring and another four are purchased in the fall from ranches in the offsite area around the NTS. Overall completeness for 1991 was 100 percent. Hunters in the state of Nevada donate the kidney and one leg bone from bighorn sheep harvested during the winter hunting season and offsite residents donate locally grown fruits and vegetables. Because these are voluntary contributions, no expected number of samples can be determined for estimation of completeness. Occasionally, road kills or other animals from the NTS are included in the Animal Investigation program, such as the mountain lion obtained by hunting in 1991. These "targets of opportunity" are not included in calculation of percent completeness.

Completeness for the PIC network can be quantified by the number of weeks for which there are average gamma exposure rates recorded for the 29 PICs. Completeness would be 100% if there were 1,508 (29 stations multiplied by 52 weeks) recorded weekly averages. Using this method, the PIC data is 99.2% complete. The stations for which data were unavailable for specific weeks are listed in Section 5.2.2.

12.4.2 PRECISION

Precision is monitored through analysis of duplicate samples. Field duplicates (e.g., a second sample collected immediately after the routine sample) are collected in the LTHMP and Milk Surveillance networks. Two TLDs, each with three identical phosphors, are deployed to each fixed station, providing a total of six replicates. Noble gas samples are split to provide duplicate samples for analysis. Animal tissue, vegetable, and human urine samples are also split after processing. A second air sampler is collocated with the routine sampler to provide a field duplicate. A total of four samplers are used; these second samplers are moved to various site locations throughout the year. In lieu of field duplicates, precision for the PICs is determined by the variance of measurements over a specific time interval when only background activities are being measured. Precision may also be determined for repeated analyses of laboratory spiked samples. These QC samples are generally not blind to the analyst; e.g., the analyst both recognizes the sample as a QC sample and knows the expected (theoretical) activity of the sample.

Precision is expressed as percent relative standard deviation (%RSD), calculated by:

$$\%RSD = \left(\frac{std.\ dev.}{mean}\right) x100$$

For duplicate sample pairs, the standard deviation is equal to the absolute value of the difference between the analytical results. The precision or %RSD is not reported for duplicate pairs in which one or both results are less than the MDA of the analysis. For most analyses, the DQOs for precision are defined for two ranges: values greater than or equal to the MDA but less than 10 times the MDA and values equal to or greater than 10 times the MDA.

Figure 12.1 displays %RSDs for LTHMP field and spiked sample duplicate pairs analyzed by the conventional tritium method. Three field duplicate pair %RSDs are not included in the figure; these three pairs had means of 5046; 98,470; and 144,650 pCi/L and %RSDs of 12.3, 0.3, and 0.2 percent, respectively. All pairs yielded %RSDs of less than 20 percent. Only three pairs were greater than 10 times the MDA; the %RSDs for these pairs were less than 2 percent. These results are better than the DQOs of 30 percent for values equal to or greater than the MDA but less than 10 times the MDA and 10 percent for values equal to or greater than 10 times the MDA. Figure 12.2 displays %RSDs for duplicate pairs analyzed by the enriched tritium method. Only three %RSDs exceeded the DQO of 30 percent for values greater than or equal to the MDA but less than 10 times the MDA and all of the duplicate pairs greater than or equal to 10 times the MDA yielded %RSDs less than the DQO of 20 percent. Two pairs with means of 836 and 521 pCi/L and %RSDs of 1.0 and 5.2 percent, respectively, are not shown on the figure.

In the ASN, field duplicate pairs are analyzed for gross alpha and gross beta and laboratory spiked sample pairs are analyzed for $^{239+240}Pu$. Gross alpha analysis was initiated late in the year and only 7 sets of duplicates were analyzed, only one of which was greater than or equal to 10 times the MDA. The %RSDs were generally less than 30 percent, although there are an insufficient number of points to draw definitive conclusions regarding achieved precision. As shown in Figure 12.3, gross beta analyses yielded %RSDs ranging from less than one percent to greater than 95 percent for duplicate pairs greater than or equal to the MDA but less than 10 times the MDA. With the exception of one pair, all of the %RSDs for pairs greater than 10 times the MDA were less than 20 percent. All of the spiked sample pairs analyzed for

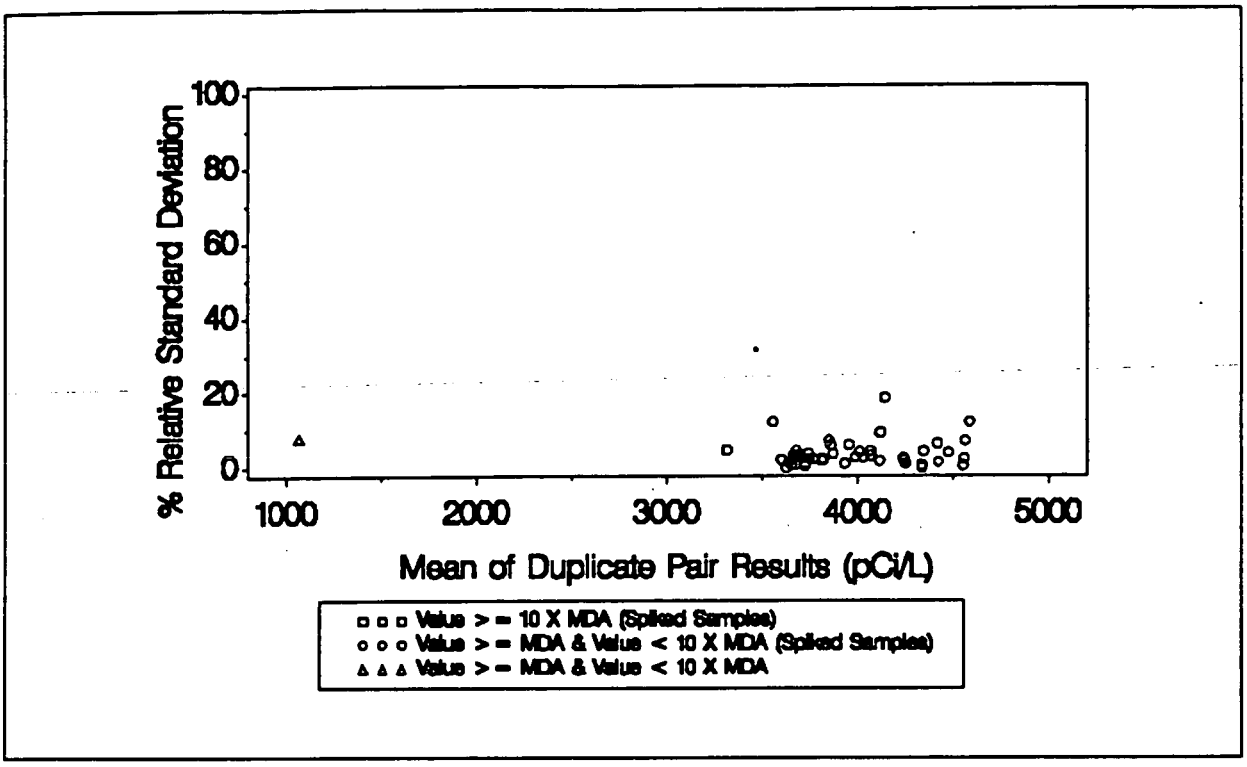

Figure 12.1 Duplicate Pair Precision for LTHMP Conventional Tritium Analyses

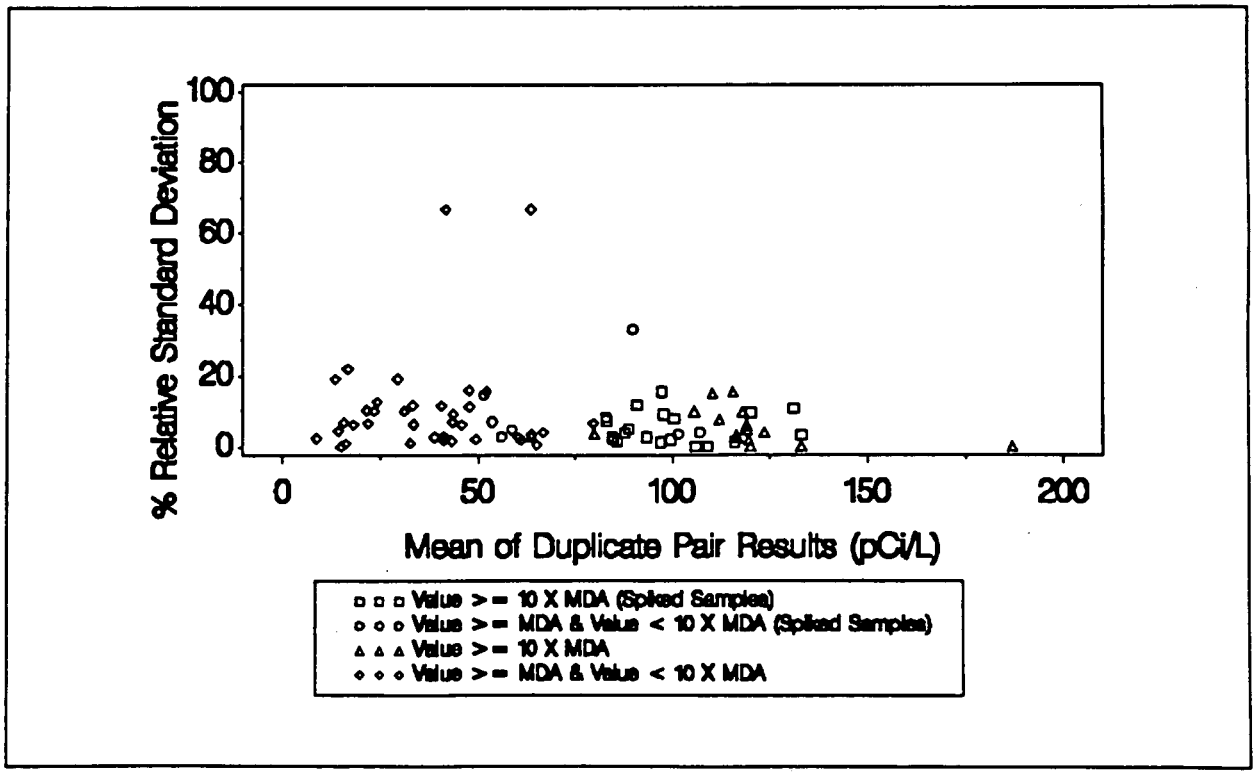

Figure 12.2 Duplicate Pair Precision for LTHMP Enriched Tritium Analyses

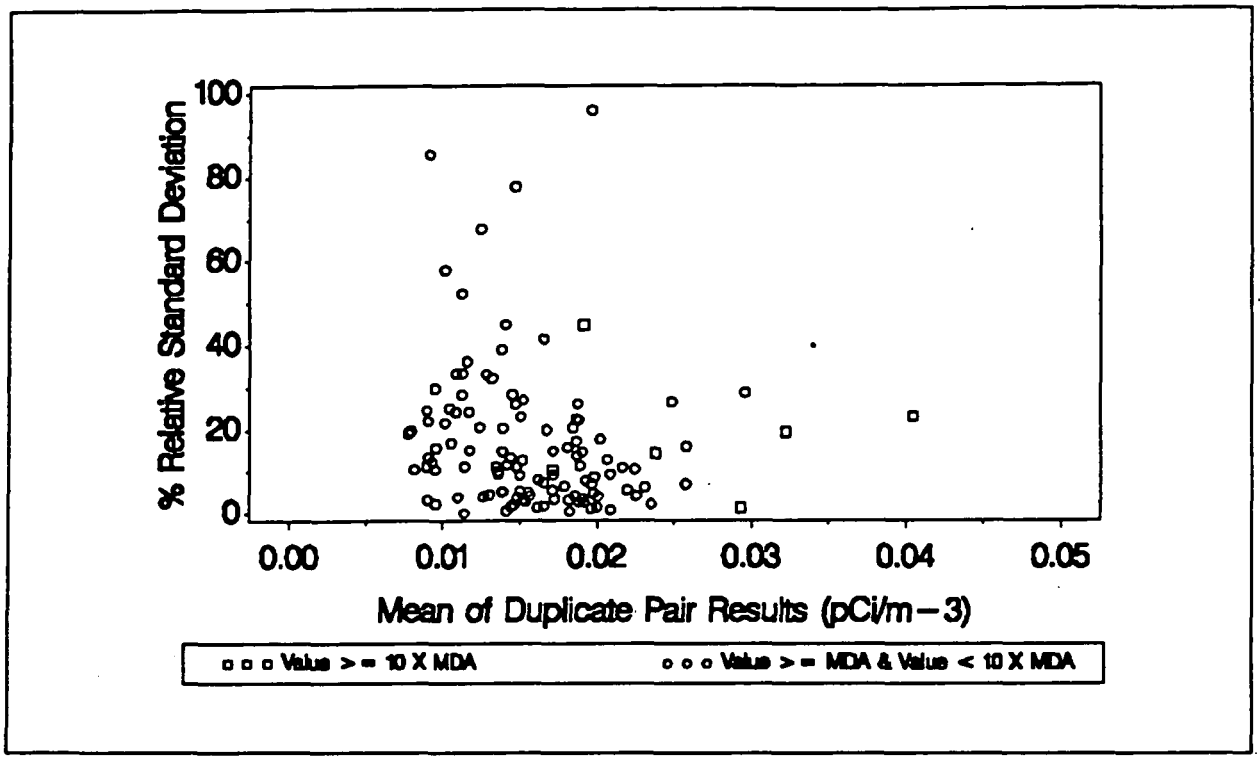

Figure 12.3 Duplicate Pair Precision for Air Surveillance Network Gross Beta Analyses

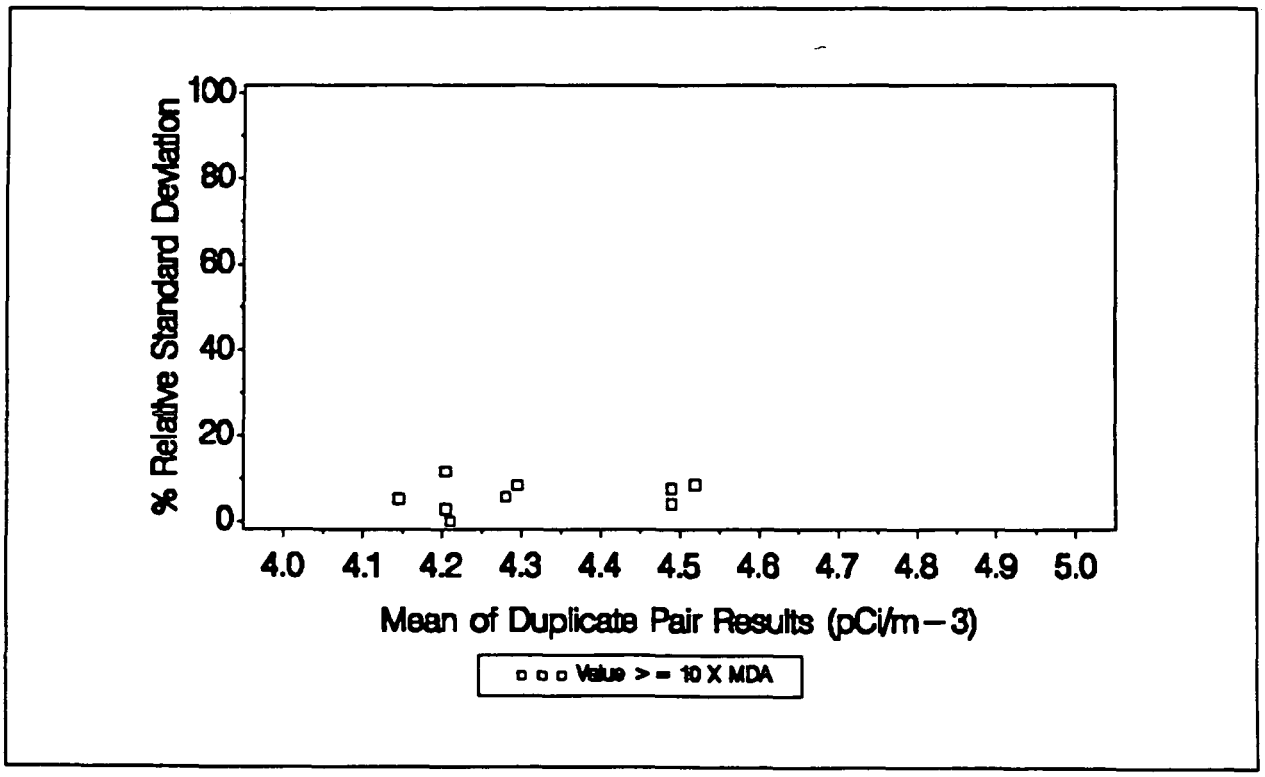

Figure 12.4 Duplicate Pair Precision for Air Surveillance Network $^{239+240}$Pu Analyses

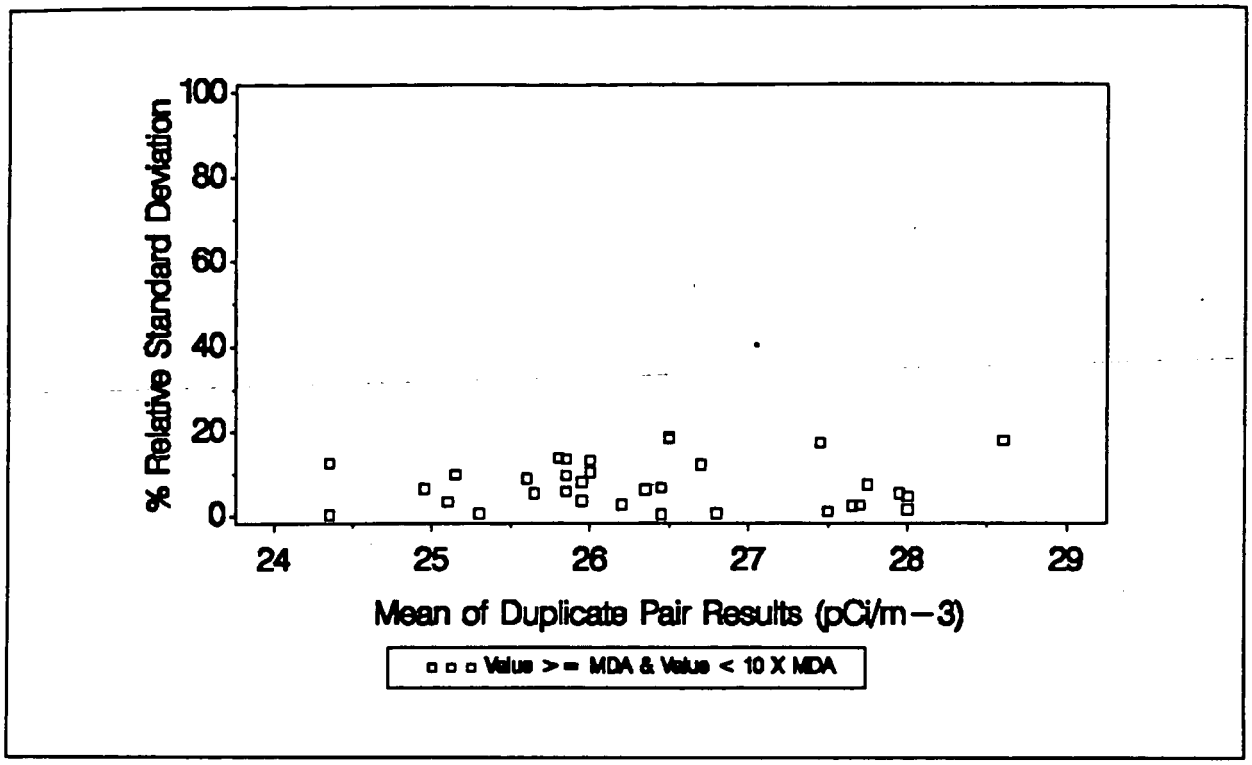

Figure 12.5 Duplicate Pair Precision for Noble Gas Network ^{85}Kr Analyses

$^{239+240}Pu$ were greater than or equal to 10 times the MDA. All %RSDs were less than the DQO of 20 percent, as shown in Figure 12.4.

All of the noble gas sample splits analyzed for ^{85}Kr had activities greater than or equal to the MDA but less than 10 times the MDA. All %RSDs were less than 20 percent, better than the DQO of 30 percent for sample pairs in this activity range. The %RSDs for ^{85}Kr are shown in Figure 12.5.

Only four of the duplicate pairs analyzed in the tritium-in-air network yielded results greater than the MDA. The %RSDs for these were all less than 20 percent, but the number of points is insufficient to draw definitive conclusions regarding achieved precision. None of the duplicate pairs from the MSN analyzed for tritium yielded results greater than the MDA. Similarly, only four animal tissue duplicate pairs were analyzed, yielded insufficient information to determine achieved precision.

A review of fixed environmental station TLD results for 1991 showed an average %RSD of 21.6 percent. A study conducted by the Nuclear Regulatory Commission (NRC) indicated an average total net field exposure uncertainty for fixed environmental station TLDs of 21.1 percent, based on a deployment period of 90 days and an average net field exposure of 22.8 mR (Nuclear Regulatory Commission, 1991). Components of the uncertainty include energy directional response, fading, calibration, exposures received while in storage, and random statistical uncertainty.

Precision for the PIC data was estimated by the agreement between continuous background gamma radiation measurements for given periods of time. Although this method does not provide an independent assessment of precision (e.g., not derived from a second collocated

PIC), it is a justifiable estimation of precision because background radiation levels at each station are relatively stable. Precision between the 4-hour averages transmitted from each PIC location are examined weekly and are used as a tool to identify equipment problems. The precision between weeks for 1991 is expressed as percent relative standard deviation (%RSD) or coefficient of variation. The %RSD can be calculated for each station by dividing the standard deviation of the weekly averages by the mean of the weekly averages (standarddeviations and means of the PIC data are given in Section 5.2.2). The %RSD for each PIC station in 1991 was less than 5% except the Austin and Rachel stations. The Austin PIC had a between-week %RSD of 13% and the Rachel station had a between-week %RSD of 8%. The variability in the Austin PIC is probably due to seasonal differences. The variability in the PIC at Rachel is possibly due to seasonal differences but could also be partially due to equipment problems. The variability in the Rachel PIC is currently under investigation.

In addition to examination of %RSDs for individual duplicate pairs, an overall precision estimate was determined by calculating the pooled standard deviation. To convert to a unitless value, the pooled standard deviation was divided by the grand mean and multiplied by 100 to yield a %RSD. Table 12.2 presents the pooled data and estimates of overall precision. With the exception of gross alpha, the achieved precision is essentially equal to or better than the DQO for the analysis and activity range. The achieved precision for gross alpha is based on a limited number of duplicate pairs analyzed in the last quarter of 1991.

12.4.3 ACCURACY

The accuracy of all analyses is controlled through the use of approved or NIST-traceable standards in instrument calibrations. Internal checks of instrument accuracy may be periodically performed, using spiked and blank matrix samples. These internal QC procedures are the only control of accuracy for whole body and lung counts and PICs. For spectroscopic and radiochemical analyses, an independent measurement of accuracy is provided by participation in intercomparison studies using samples of known activities. The EPA EMSL-LV Radioanalysis Laboratory participates in two such intercomparison studies. An independent verification of the accuracy of the TLDs is achieved through participation in DOELAP. Additionally, bone ash samples spiked with a known activity of particular radionuclides are submitted to the contract laboratory which performs analysis of animal tissue samples.

In the EPA EMSL-LV Intercomparison Study program, samples of known activities of selected radionuclides are sent to participating laboratories on a set schedule throughout the year. Water, milk, and air filters are used as the matrices for these samples. Results from all participating laboratories are compiled and statistics computed comparing each laboratory's results to the known value and to the average of all laboratories. The comparison to the known value provides an independent assessment of accuracy for each participating laboratory. Comparison of results among all participating laboratories provides a measure of comparability, discussed in Section 12.4.4. Approximately 70 to 190 laboratories participate in any given intercomparison study. Table 12.3, presents results for all intercomparison studies.

Table 12.2 Overall Precision of Analysis

Network	Analysis	Sample Type	Range	n	Pooled Standard Deviation	%RSD
LTHMP	Conv. Tritium	Spiked	≥MDA,<10x MDA	47	226.62	5.6
	Enrich. Tritium	Spiked	≥MDA,<10x MDA	8	11.21	14.1
	Enrich. Tritium	Spiked	≥10x MDA	20	6.97	7.0
	Enrich. Tritium	Field	≥10x MDA	18	9.98	5.6
Air Surveil-lance	Gross Alpha	Field	≥MDA,<10x MDA	6	0.001	39.9
	Gross Beta	Field	≥MDA,<10x MDA	113	0.003	22.4
	Gross Beta	Field	≥10x MDA	6	0.006	22.0
	$^{239+240}Pu$	Spiked	≥10x MDA	9	0.295	6.8
Noble Gas	^{85}Kr	Split	≥MDA,<10x MDA	33	2.49	9.4
Tritium in Air	HTO	Split	≥MDA,<10x MDA	4	0.83	10.7

Table 12.3 Accuracy of Analysis from EPA Intercomparison Studies

Nuclide	Month	Known Value (pCi/L)[a]	Laboratory Average (pCi/L)[a]	Percent Bias
		Water Intercomparison Studies		
Alpha	Jan	5.0	ND	
Alpha	April (PE)	54.0	67.33	24.7
Alpha	May	24.0	ND	
Alpha	Sept	10.0	9.00	-10.0
Alpha	Oct (PE)	82.0	97.67	19.1
Beta	Jan	5.0	ND	
Beta	April (PE)	115.0	ND	
Beta	May	46.0	ND	
Beta	Sept	20.0	20.00	0.0
Beta	Oct (PE)	65.0	61.67	-5.1
^{60}Co	Feb	40.0	36.67	-8.3
^{60}Co	June	10.0	ND	
^{60}Co	Oct	29.0	28.67	-1.1
^{60}Co	Oct (PE)	20.0	19.67	-1.6
^{65}Zn	Feb	149.0	141.33	-5.1
^{65}Zn	June	108.0	ND	
^{65}Zn	Oct	73.0	75.67	3.7
^{106}Ru	Feb	186.0	174.33	-6.3
^{106}Ru	June	149.0	ND	
^{106}Ru	Oct	199.0	180.67	-9.2

Table 12.3 (Accuracy of Analysis from EPA Intercomparison Studies, cont.)

Nuclide	Month	Known Value (pCi/L)[a]	Laboratory Average (pCi/L)[a]	Percent Bias
		Water Intercomparison Studies *(cont.)*		
^{134}Cs	Feb	8.0	7.33	-8.4
^{134}Cs	April (PE)	24.0	18.67	-22.2
^{134}Cs	June	15.0	ND	
^{134}Cs	Oct	10.0	10.0	0.0
^{134}Cs	Oct (PE)	10.0	9.33	-6.7
^{137}Cs	Feb	8.0	8.33	4.1
^{137}Cs	April (PE)	25.0	20.00	-20.0
^{137}Cs	June	14.0	ND	
^{137}Cs	Oct	10.0	10.33	3.3
^{137}Cs	Oct (PE)	11.0	12.00	9.1
^{133}Ba	Feb	75.0	74.67	-0.4
^{133}Ba	June	62.0	ND	
^{133}Ba	Oct	98.0	90.33	-7.8
^{3}H	Feb	4418.0	4613.00	4.4
^{3}H	Oct	2452.0	2499.33	1.9
^{131}I	Feb	75.0	81.67	8.9
^{131}I	Aug	20.0	21.33	6.6
^{226}Ra	Mar	31.8	31.60	-0.6
^{226}Ra	April (PE)	8.0	8.10	1.2
^{226}Ra	July	15.9	ND	
^{226}Ra	Oct (PE)	22.0	ND	
^{226}Ra	Nov	6.5	ND	
^{228}Ra	Mar	21.1	ND	
^{228}Ra	April (PE)	15.2	11.33	-25.5
^{228}Ra	July	16.7	ND	
^{228}Ra	Oct (PE)	22.2	ND	
^{228}Ra	Nov	8.1	ND	
^{89}Sr	April (PE)	28.0	22.33	-20.2
^{89}Sr	May	39.0	34.33	-12.0
^{89}Sr	Sept	49.0	39.67	-19.0
^{89}Sr	Oct (PE)	10.0	8.33	-16.7
^{90}Sr	April (PE)	26.0	23.33	-10.3
^{90}Sr	May	24.0	24.00	0.0
^{90}Sr	Sept	25.0	23.67	-5.3
^{90}Sr	Oct (PE)	10.0	10.33	3.3
U (Nat)	Mar	7.6	7.67	0.9
U (Nat)	April (PE)	29.8	30.30	1.7
U (Nat)	July	14.2	14.43	1.6
U (Nat)	Oct (PE)	13.5	13.17	-2.4
U (Nat)	Nov	24.9	23.97	-3.7
^{239}Pu	Aug	19.4	18.23	-6.0

Table 12.3 (Accuracy of Analysis from EPA Intercomparison Studies, cont.)

Nuclide	Month	Known Value (pCi/L)[a]	Laboratory Average (pCi/L)[a]	Percent Bias
		Air Intercomparison Studies		
Alpha	Mar	25.0	ND	
Alpha	Mar	5.0	6.00	20.0
Alpha	Aug	25.0	ND	
Alpha	Aug	10.0	14.00	40.0
Beta	Mar	124.0	ND	
Beta	Mar	31.0	36.67	18.3
Beta	Aug	92.0	ND	
Beta	Aug	62.0	80.33	29.6
^{90}Sr	Mar	40.0	ND	
^{90}Sr	Mar	10.0	11.0	10.0
^{90}Sr	Aug	30.0	29.33	-2.2
^{90}Sr	Aug	20.0	18.67	-6.6
^{137}Cs	Mar	40.0	42.33	5.8
^{137}Cs	Mar	10.0	10.67	6.7
^{137}Cs	Aug	30.0	31.33	4.4
^{137}Cs	Aug	20.0	22.33	11.6
		Milk Intercomparison Studies		
^{89}Sr	Apr	32.0	29.67	-7.3
^{89}Sr	Apr	23.0	18.67	-18.8
^{89}Sr	Sept	25.0	22.33	-10.7
^{89}Sr	Sept	16.0	12.67	-20.8
^{90}Sr	Apr	32.0	32.00	0.0
^{90}Sr	Apr	23.0	19.67	-14.5
^{90}Sr	Sept	25.0	25.33	1.3
^{90}Sr	Sept	20.0	18.00	-10.0
^{131}I	Apr	60.0	59.33	-1.1
^{131}I	Apr	99.0	98.00	-1.0
^{131}I	Sept	108.0	108.33	0.3
^{131}I	Sept	58.0	63.33	9.2
^{137}Cs	Apr	49.0	45.33	-7.5
^{137}Cs	Apr	24.0	25.33	5.5
^{137}Cs	Sept	30.0	31.67	5.6
^{137}Cs	Sept	20.0	20.33	1.6
K (tot)	Apr	1650.0	1212.67	-26.5
K (tot)	Apr	1550.0	1587.33	2.4
K (tot)	Sept	1740.0	1710.67	-1.7
K (tot)	Sept	1700.0	1754.67	3.2

(a) Values were obtained from the individual intercomparison study reports and are reported with the significant figures included in those reports.

provided. Accuracy, as percent difference or percent bias, is calculated by:

$$\%BIAS = \left(\frac{C_m - C_a}{C_a}\right) 100$$

where
%BIAS = percent bias
C_m = measured sample activity
C_a = known sample activity

In most cases, the achieved accuracy was well within the established DQOs for the analysis. In general, these DQOs are ± 20 percent for values greater than ten times the MDA and ± 30 percent for results greater than the MDA but less than ten times the MDA. The DQO was exceeded for one alpha intercomparison sample in water and one in air, one beta intercomparison sample in air, one ^{137}Cs intercomparison sample in water, one ^{89}Sr intercomparison sample in water and one in milk, and one total potassium intercomparison sample in milk.

The other intercomparison study in which the EPA EMSL-LV Radioanalysis Laboratory participates is the semiannual DOE QA Program conducted by EML in New York, NY. Approximately 20 laboratories participate in this intercomparison study program, although each laboratory receives only its own results and the EML value. The EML result is assumed to represent the known or true activity. Results for all analysis are given in Table 12.4. In all

Table 12.4 Accuracy of Analysis from DOE Intercomparison Study

Nuclide	Month	EML Value (pCi/L)[a]	EPA Value (pCi/L)[a]	Percent Bias
		Water Intercomparison Studies		
^{144}Ce	Mar	35.1	39.2	11.7
^{144}Ce	Sept	226	214	-5.3
^{57}Co	Mar	230	214	-7.0
^{57}Co	Sept	166	174	4.8
^{60}Co	Mar	201	191	-5.0
^{60}Co	Sept	291	294	1.0
^{137}Cs	Mar	169	163	-3.5
^{137}Cs	Sept	46.0	48.3	5.0
^{3}H	Sept	100	102	2.0
^{54}Mn	Mar	213	206	-3.3
^{54}Mn	Sept	103	104	1.0
^{90}Sr	Sept	10.1	9.93	-1.7
U (Nat)	Sept	0.940	0.949	1.0
^{239}Pu	Sept	0.510	0.480	-5.9

Table 12.4 (Accuracy of Analysis from DOE Intercomparison Study, cont.)

Nuclide	Month	EML Value (pCi/L)[a]	EPA Value (pCi/L)[a]	Percent Bias
		Air Intercomparison Studies		
^{7}Be	Mar	53.0	47.8	-9.8
^{7}Be	Sept	53.8	56.4	4.8
^{144}Ce	Mar	52.2	52.9	1.3
^{144}Ce	Sept	50.8	56.0	10.2
^{57}Co	Mar	5.82	5.44	-6.5
^{57}Co	Sept	16.6	19.3	16.3
^{60}Co	Mar	5.14	4.92	-4.3
^{60}Co	Sept	23.0	24.5	6.5
^{137}Cs	Mar	4.53	4.70	3.7
^{137}Cs	Sept	28.0	30.1	7.5
^{54}Mn	Mar	4.80	4.85	1.0
^{54}Mn	Sept	24.3	26.4	8.6
^{239}Pu	Sept	0.084	0.087	3.6
		Vegetation Intercomparison Studies		
^{239}Pu	Sept	0.365	0.359	-1.6
		Soil Intercomparison Studies		
^{239}Pu	Sept	7.35	7.22	-1.8

(a) Values were obtained from the Environmental Measurements Laboratory (EML) and reported with the significant figures provided by EML.

cases, the EPA results differed from the EML known activities by a percent bias of less than ± 10 percent. These results exceed the established DQO.

In addition to use of irradiated control samples in the processing of TLDs, DOELAP monitors accuracy as part of the accreditation program. As with the intercomparison studies, samples of known activity are submitted as single blind samples. The designation "single blind" indicates the analyst recognizes the sample as being other than a routine sample, but does not know the concentration or activity contained in the sample. Individual results are not provided to the participant laboratories by DOELAP; issuance of the accreditation certificate indicates acceptable accuracy has been achieved as one of the accreditation criteria.

12.4.4 COMPARABILITY

The EPA Intercomparison Study reports (EPA, 1981) provide results for all laboratories participating in each intercomparison study. A grand average is computed for all values, excluding outliers. A normalized deviation statistic compares each laboratory's result (mean of three replicates) to the known value and to the grand average. If the value of this statistic (in

multiples of standard normal deviate, unitless) lies between control limits of -3 and +3, the accuracy (deviation from known value) or comparability (deviation from grand average) is within normal statistical variation. Table 12.5 displays data from the 1991 intercomparison studies for all variables measured. Of the commonly measured variables, there were three instances in which the Radioanalysis Laboratory results deviated from the grand average by more than three standard normal deviate units. These were the April intercomparison sample for total potassium in milk, the August sample for beta emitters on an air filter, and the September water intercomparison sample containing ^{89}Sr. The first two of these also exceeded the DQO for accuracy (see Section 12.4.3, above). The third sample, ^{89}Sr in water, was within the DQO for accuracy. Apart from these three, all of the normalized deviations from the grand average were within the statistical control limit range of -3 to +3. This indicates acceptable comparability of the Radioanalysis Laboratory with the 69 to 207 laboratories participating in the EPA Intercomparison Study Program.

12.4.5 REPRESENTATIVENESS

Representativeness cannot be evaluated quantitatively. Rather, it is a qualitative assessment of the ability of the sample to model the objectives of the program. The primary objective of the ORSP is to protect the health and safety of the offsite residents. Therefore, the DQO of representativeness is met if the samples are representative of the radiation exposure of the resident population. Monitoring stations are located in resident population centers. Siting criteria specific to radiation sensors are not available for many of the instruments used. Existing siting criteria developed for other pollutants are applied to the ORSP sensors as available. For example, siting criteria for the placement of air sampler inlets are contained in Prevention of Significant Deterioration guidance documents (EPA, 1976). Inlets for the air samplers at the ORSP stations have been evaluated against these criteria and, in most cases, meet the siting requirements. Guidance or requirements for handling, shipping, and storage of radioactivity samples are followed in program operations and documented in SOPs. Standard analytical methodology is used and guidance on the holding times for samples, sample processing, and results calculations are followed and documented in SOPs.

In the LTHMP, the primary objectives are protection of drinking water supplies and monitoring of any potential cavity migration. Sampling locations are primary "targets of opportunity", i.e., the sampling locations are primarily wells developed for other purposes than radioactivity monitoring. Guidance or requirements developed for CERCLA and RCRA regarding the number and location of monitoring wells has not been applied to the LTHMP sampling sites. In spite of these limitations, the samples are representative of the first objective, protection of drinking water supplies. At all of the LTHMP monitoring areas, including on and around the NTS, all potentially impacted drinking water supplies are monitored, as are many supply sources with virtually no potential to be impacted by radioactivity resulting from past or present nuclear weapons testing. The sampling network at some locations is not optimal for achieving the second objective, monitoring of any migration of radionuclides from the test cavities. An evaluation conducted by DRI describes, in detail, the monitoring locations for each LTHMP location and the strengths and weaknesses of each monitoring network (Chapman and Hokett, 1991). This evaluation is cited in the discussion of the LTHMP data in Sections 9.2 and 9.3.

Table 12.5 Comparability of Analysis from EPA Intercomparison Studies[a]

Nuclide	Month	Number of Labs. Participating	EPA Lab. Average pCi/L	Grand Average pCi/L	Normalized Deviation from Grand Average	Ratio EPA Laboratory Average/Grand Average
		Water Intercomparison Studies				
Alpha	Jan	198	ND	5.69	NA	
Alpha	April (PE)	179	67.33	49.71	2.18	1.35
Alpha	May	209	ND	20.94	NA	
Alpha	Sept	207	9.00	10.36	-0.47	0.87
Alpha	Oct (PE)	187	97.67	75.57	1.82	1.29
Beta	Jan	198	ND	6.60	NA	
Beta	April (PE)	179	ND	108.60	NA	
Beta	May	209	ND	44.73	NA	
Beta	Sept	207	20.00	20.30	-0.10	0.99
Beta	Oct (PE)	187	61.67	55.53	1.06	1.11
^{60}Co	Feb	151	36.67	40.04	-1.17	0.92
^{60}Co	June	159	ND	10.69	NA	
^{60}Co	Oct	162	28.67	29.83	-0.40	0.96
^{60}Co	Oct (PE)	187	19.67	20.22	-0.19	0.97
^{65}Zn	Feb	151	141.33	149.71	-0.97	0.94
^{65}Zn	June	159	ND	109.54	NA	
^{65}Zn	Oct	162	75.67	74.57	0.27	1.01
^{106}Ru	Feb	151	174.33	191.83	-1.60	0.91
^{106}Ru	June	159	ND	141.48	NA	
^{106}Ru	Oct	162	180.67	194.21	-1.17	0.93
^{134}Cs	Feb	151	7.33	8.09	-0.26	0.91
^{134}Cs	April (PE)	179	18.67	22.96	-1.49	0.81
^{134}Cs	June	159	ND	14.2	NA	
^{134}Cs	Oct	162	10.0	9.93	0.02	1.01
^{134}Cs	Oct (PE)	187	9.33	9.58	-0.08	0.97
^{137}Cs	Feb	151	8.33	9.06	-0.25	0.92
^{137}Cs	April (PE)	179	20.00	25.49	-1.90	0.78
^{137}Cs	June	159	ND	15.37	NA	
^{137}Cs	Oct	162	10.33	10.86	-0.18	0.95
^{137}Cs	Oct (PE)	187	12.00	12.45	-0.15	0.96
^{133}Ba	Feb	151	74.67	74.14	0.11	1.01
^{133}Ba	June	159	ND	61.37	NA	
^{133}Ba	Oct	162	90.33	95.56	-0.91	0.95
^{3}H	Feb	150	4613.00	4437.54	0.69	1.04
^{3}H	Oct	166	2499.33	2531.91	-0.16	0.99
^{131}I	Feb	120	81.67	77.00	1.01	1.06
^{131}I	Aug	113	21.33	20.96	0.11	1.02
^{226}Ra	Mar	115	31.60	29.45	0.77	1.07
^{226}Ra	April (PE)	179	8.10	7.72	0.55	1.05
^{226}Ra	July	120	ND	15.34	NA	
^{226}Ra	Oct (PE)	187	ND	21.57	NA	
^{226}Ra	Nov	121	ND	6.38	NA	

Table 12.5 (Comparability of Analysis from EPA Intercomparison Studies*, cont.)

Nuclide	Month	Number of Labs. Participating	EPA Lab. Average pCi/L	Grand Average pCi/L	Normalized Deviation from Grand Average	Ratio EPA Laboratory Average/Grand Average
		Water Intercomparison Studies *(cont.)*				
^{228}Ra	Mar	115	ND	19.14	NA	
^{228}Ra	April (PE)	179	11.33	14.01	-1.22	0.81
^{228}Ra	July	120	ND	15.63	NA	
^{228}Ra	Oct (PE)	187	ND	21.12	NA	
^{228}Ra	Nov	121	ND	8.19	NA	
^{89}Sr	April (PE)	179	22.33	25.74	-1.18	0.87
^{89}Sr	May	104	34.33	37.43	-1.07	0.92
^{89}Sr	Sept	69	39.67	49.57	-3.43*	0.80
^{89}Sr	Oct (PE)	187	8.33	9.79	-0.51	0.85
^{90}Sr	April (PE)	179	23.33	23.61	-0.10	0.99
^{90}Sr	May	104	24.00	28.85	0.05	0.83
^{90}Sr	Sept	69	23.67	24.72	-0.46	0.96
^{90}Sr	Oct (PE)	187	10.33	10.09	0.08	1.02
U (Nat)	Mar	117	7.67	7.30	0.21	1.05
U (Nat)	April (PE)	179	30.30	28.88	0.82	1.05
U (Nat)	July	127	14.43	13.38	0.61	1.08
U (Nat)	Oct (PE)	187	13.17	13.25	-0.05	0.99
U (Nat)	Nov	90	23.97	23.76	0.12	1.01
^{239}Pu	Aug	61	18.23	19.22	-0.90	0.95
		Air Intercomparison Studies				
Alpha	Mar	165	ND	29.73	NA	
Alpha	Mar	185	6.00	6.25	-0.09	0.96
Alpha	Aug	172	ND	28.33	NA	
Alpha	Aug	179	14.00	12.21	0.62	1.15
Beta	Mar	165	ND	130.11	NA	
Beta	Mar	185	36.67	32.19	1.55	1.14
Beta	Aug	172	ND	95.54	NA	
Beta	Aug	179	80.33	64.66	5.43*	1.24
^{90}Sr	Mar	165	ND	39.3	NA	
^{90}Sr	Mar	185	11.0	9.69	1.51	1.14
^{90}Sr	Aug	172	29.33	29.11	0.08	1.01
^{90}Sr	Aug	179	18.67	19.45	-0.27	0.96
^{137}Cs	Mar	165	42.33	44.61	-0.79	0.95
^{137}Cs	Mar	185	10.67	11.56	-0.31	0.92
^{137}Cs	Aug	172	31.33	32.48	-0.40	0.96
^{137}Cs	Aug	179	22.33	22.70	-0.13	0.98
		Milk Intercomparison Studies				
^{89}Sr	Apr	96	29.67	27.07	0.90	1.10
^{89}Sr	Apr	104	18.67	23.14	-1.55	0.81

Table 12.5 (Comparability of Analysis from EPA Intercomparison Studies[a], cont.)

Nuclide	Month	Number of Labs. Participating	EPA Lab. Average pCi/L	Grand Average pCi/L	Normalized Deviation from Grand Average	Ratio EPA Laboratory Average/Grand Average
		Milk Intercomparison Studies, *(cont.)*				
^{90}Sr	Sept	95	22.33	20.95	0.48	1.07
^{89}Sr	Sept	98	12.67	13.53	-0.30	0.94
^{90}Sr	Apr	96	32.00	28.02	1.38	1.14
^{90}Sr	Apr	104	19.67	22.33	-0.92	0.88
^{90}Sr	Sept	95	25.33	21.09	1.47	1.20
^{90}Sr	Sept	98	18.00	17.57	0.15	1.02
^{131}I	Apr	96	59.33	61.17	-0.53	0.97
^{131}I	Apr	104	98.00	98.49	-0.09	1.00
^{131}I	Sept	95	108.33	108.56	-0.04	1.00
^{131}I	Sept	98	63.33	58.88	1.29	1.08
^{137}Cs	Apr	96	45.33	51.35	-2.08	0.88
^{137}Cs	Apr	104	25.33	24.65	0.24	1.03
^{137}Cs	Sept	95	31.67	31.35	0.11	1.01
^{137}Cs	Sept	98	20.33	21.47	-0.39	0.95
K (tot)	Apr	96	1212.67	1653.09	-9.19*	0.73
K (tot)	Apr	104	1587.33	1548.38	0.86	1.03
K (tot)	Sept	95	1710.67	1667.46	0.86	1.03
K (tot)	Sept	98	1754.67	1713.52	0.84	1.02

(a) Values were obtained from the individual intercomparison study reports and are reported with the significant figures included in those reports.
PE = performance evaluation study.
(Nat) = natural.
* = outside control limits.

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